# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chairmans Report</td>
<td>1</td>
</tr>
<tr>
<td>Department News</td>
<td>3</td>
</tr>
<tr>
<td>Clinical Sections</td>
<td>7</td>
</tr>
<tr>
<td>Abdominal Imaging</td>
<td>7</td>
</tr>
<tr>
<td>Breast Imaging</td>
<td>9</td>
</tr>
<tr>
<td>Musculoskeletal Imaging</td>
<td>10</td>
</tr>
<tr>
<td>Neuroradiology</td>
<td>11</td>
</tr>
<tr>
<td>Nuclear Medicine</td>
<td>13</td>
</tr>
<tr>
<td>Pediatric Imaging</td>
<td>14</td>
</tr>
<tr>
<td>Thoracic Imaging</td>
<td>15</td>
</tr>
<tr>
<td>Vascular and Interventional Radiology</td>
<td>16</td>
</tr>
<tr>
<td>Research</td>
<td>17</td>
</tr>
<tr>
<td>Paul C. Hodges Alumni Society</td>
<td>42</td>
</tr>
<tr>
<td>Educational Programs</td>
<td>44</td>
</tr>
<tr>
<td>Fellowship Programs</td>
<td>44</td>
</tr>
<tr>
<td>Diagnostic Radiology Residency</td>
<td>45</td>
</tr>
<tr>
<td>Medical Student Education</td>
<td>47</td>
</tr>
<tr>
<td>Graduate Program in Medical Physics</td>
<td>47</td>
</tr>
<tr>
<td>Faculty Achievements</td>
<td>54</td>
</tr>
<tr>
<td>Honors &amp; Awards</td>
<td>54</td>
</tr>
<tr>
<td>Society Offices &amp; Committees</td>
<td>54</td>
</tr>
<tr>
<td>Editorial Board Memberships</td>
<td>56</td>
</tr>
<tr>
<td>Manuscript Reviewers</td>
<td>57</td>
</tr>
<tr>
<td>Scientific Presentations</td>
<td>59</td>
</tr>
<tr>
<td>Invited Presentations</td>
<td>62</td>
</tr>
<tr>
<td>Exhibits</td>
<td>64</td>
</tr>
<tr>
<td>Patents</td>
<td>65</td>
</tr>
<tr>
<td>Peer-Reviewed Publications</td>
<td>65</td>
</tr>
<tr>
<td>Invited Publications</td>
<td>70</td>
</tr>
<tr>
<td>Abstracts and Proceedings</td>
<td>71</td>
</tr>
<tr>
<td>Chapters, Books, and Review Articles</td>
<td>74</td>
</tr>
<tr>
<td>Grants and Contracts</td>
<td>74</td>
</tr>
<tr>
<td>Radiology Celebrates</td>
<td>78</td>
</tr>
<tr>
<td>Department Administration</td>
<td>81</td>
</tr>
</tbody>
</table>
The 2007 – 2008 academic year was one of many accomplishments for the Department of Radiology. The key role the department holds at the University of Chicago Medical Center is evident throughout this report in all aspects of our missions -- forefront and compassionate clinical care, outstanding educational programs, and leading basic and clinical research. This report provides depth and detail on the department activities but as Chair I would like to highlight some of the activities of the Department.

Clinical Service

Clinical activity in the Department continued to expand at a seemingly endless pace. Key perspectives on this growth became clear to me when I came across an old document from a few years back detailing the growth in clinical activity for the Department between 1998 and 2004. I thought it of interest to look at a decade’s growth to 2008 of radiology activity at the University of Chicago Medical Center. Total procedural volume grew from 184,000 to nearly 300,000 procedures, almost doubling. This statistic in itself is misleading in terms of clinical activity, as general radiology, our simplest least time consuming procedure showed a basically flat volume of approximately 100,000 procedures. The CT volume grew from 22,600 to 61,300; the MR volume from 7000 to 17,000! These current volumes represent more than a doubling of the effort of the faculty and staff and a substantially increased impact on patient care. And in addition, in 2004, the Department began providing radiology services at Weiss Hospital.

The 2007 – 2008 year was one of increasing productivity with little increases in new equipment. The CT team awaits the installation of the new 256 slice scanner, originally scheduled for February of 2008, but construction delays have backed this up to early fall. The new 1.5T MR center in Mitchell Hospital Radiology opened in fall of 2007, but did not increase capacity as we closed one unit for renovation. The new clinical 3T MR scanner installation has been delayed until early 2009. Despite the lack of new equipment, CT and MR volumes continued to increase compared with most recent years as shown in the accompanying graphs:

With the installation of our new speech recognition dictation system from Commissure, our report turnaround time markedly decreased, and now averages 12 hours for all studies, with most completed in several hours. The impact we now provide to patient care has substantially increased in many ways --- patient studies can be completed and the patient seen in specialty clinics immediately following with a report in the medical record system. What a dramatic change from just several years ago (2004) when the average turnaround time was 84 hours!

Teaching Programs

Throughout this report you will see the contributions of our trainees from the radiology residency and the medical physics programs towards all of our missions. The diagnostic radiology residency program remains approved for 28 positions, but late in the year we started planning for the new academic affiliation with North
Shore University Health System (formerly Evanston Northwestern Hospital). It is anticipated that our radiology residents will have some of their educational rotations at that site, and that we will increase our residency size correspondingly. The residency program and its new curricular changes had demonstrable and measurable evidence of its quality and impact in the 2008 academic year. The residents from the University of Chicago taking the American Board of Radiology physics examination averaged the #1 highest scores among all North American residency programs. And at the American College of Radiology In Service examination given to all North American radiology residency programs in February, 2008 our first year residents as a group performed at the 99th percentile, and the second year residents at the 98th percentile.

Our medical physics program, in conjunction with faculty from Radiation Oncology through the Committee on Medical Physics had 30 predoctoral students during the year. As always the doctoral candidates had an outstanding academic year with five graduating. Their research accomplishments are reflected in the 24 awards (RSNA, SPIE, etc.) and 49 papers accepted for publication during the year! Currently ten of the 30 graduate students have U.S. Army predoctoral scholarships and others are funded by our Department NIH training grants. Our department has always been very popular with medical students not just for clinical elective rotations, but we have always had large numbers of students working in our research programs. All of our trainees continue to bring vitality and new ideas to our department.

Research Programs

This was an exciting year for our research programs. The Department faculty received its fourth NIH shared instrumentation grant (Dr. Chen) in 3 years and resulted in our installing a new microPET/SPECT/CT. Planning and construction continued for the installation of the new research 3T MR scanner supported by Dr. Jia-Hong Gao’s $2 million NIH large instrumentation grant received during the year with extensive renovations and sited adjacent to the new 1.5T rampable to 3T MR unit that will house the research MR guided focused ultrasound ablation. Construction delays have turned back anticipated opening to November, 2008. While all investigators nationwide, including ours, are impacted by the increasingly difficult NIH funding lines, this past year once again was a strong funding year for the Department of Radiology. The accompanying graph shows that during this academic year the Department expenditures were essentially the same as in FY 2007, reflecting over $6 million (direct and indirect) of federal grant funding, sustaining the growth from earlier in the decade. Department faculty had a success rate of over 20% on all submitted federal grant proposals during the year, a remarkable achievement in consideration of the current NIH funding climate.

Faculty Appointments and Promotions

The primary resource in the Department of Radiology has always been our faculty and through key recruits and growth we are able to provide new areas of expertise expanding into new clinical and research areas. During 2007 - 2008 new faculty joined several section. Delilah Burrowes, MD, trained in adult and pediatric neuroradiology, joined our faculty as assistant professor after serving on the Northwestern Medical School faculty...
primarily at Children’s Memorial Hospital. Vivek Sehgal, MD, a diagnostic neuroradiologist who had trained in our department and served on our faculty in the past, was recruited from a faculty position at Wayne State University to rejoin our neuroradiology section as assistant professor. Steve Zangan, MD, a former chief resident from our program completed an interventional radiology fellowship with us and joined our faculty as an assistant professor in the Interventional Radiology and Chest sections. Two faculty were promoted during the year reflecting on their accomplishments. Emil Sidky, PhD, was promoted to Research Associate (Associate Professor), and Brian Funaki, MD, chief of interventional radiology, was promoted to Professor.

The faculty, staff, and trainees in the department can be proud of the accomplishments described in this report. The Department clearly embodies the missions and goals of the University of Chicago and represents our institutions well. I hope you will take the time read this report and see the full extent of our department’s accomplishments. I am confident in doing so you will share the excitement that is evident in the department on a daily basis that characterizes the Department of Radiology. We continue to build a solid foundation for the Department and the institution to continue to be a leader in medical care and imaging for years to come.

Department News

Teaching Radiology to Medical Students in the 21st Century and Changing the Curriculum at the University of Chicago

The Radiology Department has recently been identified by the University of Chicago community as a leader in medical student education. The last several years have produced a successful drive to be innovative and construct cutting edge student programming into a new radiology curriculum for early medical student education.

An internal evaluation of the entire Pritzker Medical School curriculum was recently completed as part of a planning process for a new overall curriculum structure to be phased in over the next several years. The Radiology Department’s educational efforts were particularly cited by the BSD Dean for our innovation and we have begun to aggressively implement additional new programming that will bring imaging education front and center, integrated into a team approach to patient care, and ensuring that graduating students are well versed in imaging principles and how radiologists work in optimizing patient outcomes.

Our largest change was implementing radiology imaging education into the classroom early in the first two years of Medical School. The previous curriculum offered radiology as an elective course in the senior year. The change with concomitant teaching of pertinent material with existing required medical school basic courses serves two significant benefits. It exposes students to the imaging options and modalities and most importantly emphasizes the integration of imaging with all aspects of patient care. Radiology material not only helps coalesce concepts from basic anatomy to pathological processes; but it is appearing to have the added effect in better overall use of our hospitals imaging resources and equipment by affecting ordering habits and awareness of more focused and dedicated imaging options.

Radiology has made itself more available across the curriculum to make sure material is taught by radiologists. This move into the classroom brings a cohesive thread through the students’ curriculum and more importantly a clinical excitement to the first two years of training. The human morphology course was a natural fit at combining imaging with the lecture and dissection components and has resulted in a course that is very popular with students. This new combination precipitated the installation of flatscreen projections and use of digital imaging not just within lecture but directly and in real time to their lab sessions. Radiology went from a passive supplement to an integrated occurrence with dedicated daily sessions representing 20% of the overall material and exam in this key course.

Direct anatomic correlation is stressed in lab, integrating the knowledge and relationship of structures. This is opposed to the more traditional memorization of structures of the past. This also fosters an integrated understanding of the anatomy as seen through radiology imaging, solidifying vocabulary and an understanding which will be used for the remainder of their careers. The chance to incorporate an early dose of clinical pertinence additionally gels the experience into one which
emphasizes the fundamental concepts and is fruitful regardless of the student’s future subspecialty.

A similar approach has been employed with the Clinical Pathophysiology and Treatment course, which continues to represent the backbone of the non-clinical program. Imaging is being incorporated into existing sections and proving that a picture can speak for a 1000 words. Second year students are at this point familiar with a variety of modalities and projections, so there is little explanation needed other than discussing the pathological process being taught.

Course number 305 was completely reformulated and offered in the spring. This course is designed to appeal to first and second year students and uses pathology to reinforce basic concepts as well as exposes students to our field in more depth. It is used for Step 1 board exam preparation and is a significant pathway in bringing first year students into departmental research. Many take the course and follow up their interest with a project or the SRP program.

Students now enter the clinical clerkships with a solid awareness of what role imaging plays in patient care and basic skills to interpret studies. Our early observation is showing a suspicion that students are far more likely to use our services more effectively and efficiently. There is the hope to create and implement dedicated student level radiology rounds within the third year clerkships and this last step would complete the envisioned radiology curriculum changes, leaving the senior year free to pursue a more challenging experience that is focused on a topic or collaboration which will benefit the individual student in their chosen career.

Seniors are now offered one of several targeted electives. Listed courses have additionally been altered and updated to align with the premise that students ought to be incorporated into the daily department workflow and not just listen passively. Dedicated student lectures and online programming have been utilized and the installation of a computer lab eases access. Students are also using as well developing dedicated MIRC teaching files. Research and personalized projects have also remained available.

The newest component, in its final development, is a new spring senior course aimed at preparing all seniors for internship. We have seen a steady rise in our specialty’s interest above the average and the overall increase noted nationally. This past year alone, 10 students chose to apply and match in our field; 40% of the AOA recipients of the 2009 class.

The end result of these changes has been to increase our department teaching role and availability and the response has been overwhelming and positive.

Giger, PhD Elected President of AAPM

Maryellen L. Giger, PhD

Maryellen L. Giger, PhD, Professor of Radiology, the Committee of Medical Physics, and the College has been elected President of AAPM, the American Association of Physicists in Medicine. She is finishing her President-Elect year in 2008, followed by serving as President in 2009 and Chairman of the Board in 2010. Dr. Giger Board in 2010. Dr. Giger is also Vice Chair of Radiology for Basic Science Research, and Chair of the Committee on Medical Physics at the University of Chicago, on which she serves as director of our CAMPEP-accredited Graduate Programs in Medical Physics.

The mission of the AAPM is to advance the practice of physics in medicine and biology by encouraging innovative research and development, disseminating scientific and technical information, fostering the education and professional development of medical physicists, and promoting the highest quality medical services for patients. The AAPM is a scientific, educational, and professional organization of more than 5,000 medical physicists and is a member of the American Institute of Physics. Its publications include the scientific journal Medical Physics. Headquarters are located at the American Center for Physics in College Park, Maryland.

Many AAPM members also participate in the annual meeting of the RSNA. The AAPM enjoys a productive relationship with the RSNA in arranging the physics sessions and refresher courses at the annual RSNA meeting as well as working together on initiatives. Recent joint initiatives include the advancement of quantitative imaging in research, clinical trials, and practice, and the development of physics teaching modules for radiology residents.

Dr. Giger is most noted for her research in CAD – computer-aided diagnosis – especially in multi-modality breast imaging. Her lab has extended its research on mammography, breast ultrasound, and MRI CAD to the development of image-based methods for cancer risk assessment and for prognostic and predictive markers. In addition, her lab is investigating image-based methods of assessment of osteoporosis and osteolysis on skeletal images, analysis of cardiac CT for improved image quality and interpretation, and analysis of prostate MR images as well as investigations into effective and efficient methods for presenting CAD outputs to the end user. Her research is supported by NCI, NIBIB, NIAMS, DOD, and DOE, and she serves as co-P.I. of the University of Chicago Breast SPORE.
A New MicroPET/SPECT/CT and Ultrasound Laboratory for Imaging of Small Animals

The Department of Radiology, in collaboration with the Section of Cardiology of the Department of Medicine, has recently established a Joint Small Animal Imaging Laboratory that is equipped with a Gamma Medica Ideas (GMI) Triumph Multi-Modality Pre-Clinical MicroPET/SPECT/CT Imaging System (now distributed exclusively by GE), purchased in part with an NIH Shared Instrumentation Grant (P.I.: Chin-Tu Chen, PhD), and two VisualSonics Vevo 770 Micro-Ultrasound Imaging Systems. Chin-Tu Chen, PhD, of Radiology and Chief of Cardiology in Medicine, Stephen Archer, MD, are Faculty Co-Directors of this new laboratory. Together with the existing Optical Imaging Core Facility (Chin-Tu Chen, PhD, and Patrick La Riviere, PhD, Faculty Co-Directors) and the MRI/MRS Core Facility (Gregory Karczmar, PhD, and Brian Roman, PhD, Faculty Co-Directors), these animal imaging capabilities enable Radiology and our faculty, as well as their research collaborators throughout the BSD, to employ and utilize a full spectrum of various imaging modalities to conduct investigations involving small animal models for cancer, cardiovascular diseases, brain and behavioral disorders, and other biomedical research.

Small animal imaging methods have become powerful tools for biomedical investigation of in vivo structural/functional norms in health and alternations in disease, as well as their biochemical and physiologic bases. Imaging of small live animals longitudinally over time can provide more reliable observations and improved quantitative measures of the normal and abnormal, disease progression, tissue recovery, and responses to drugs and other therapies. Incorporation of small animal imaging has become an integral and essential component in routine biomedical research.

Establishment of this state-of-the-art animal imaging laboratory to perform PET, SPECT, CT and ultrasound imaging of small animals allows Radiology and our faculty to expand their research horizon and enhance their research potentials. Initial research projects utilizing these new imaging capabilities range from imaging for evolutionary biology and paleontology, evaluation of novel tracers and image-enhancing agents, investigation of cardiopulmonary functions, imaging for drug development and assessment of drug effects, brain imaging of animal models of various brain and behavioral disorders, to quantitative measurements of responses to radiation therapy and gene therapy, etc.

Continuous Quality Improvement Initiatives in the Department

The structure of the Continuous Quality Improvement (CQI) Committee was revamped in 2008, to optimize planning and reporting of Departmental and physician indicators. A core group, consisting of Monica Geyer, Assistant Director of Specialty Imaging, Milton Griffin, Assistant Director of General Medical Imaging, Dr. David M. Paustner, Vice Chair of Operations and Departmental Quality Chair, and Amanda Schmitz, representative from the Center on Quality, provided leadership and planning for ongoing and new projects. Physician Section Heads and Departmental managers worked in tandem with this core group as the CQI Committee.

Key Departmental indicators were tracked continuously during the year, to allow rapid comparison with goals and implementation of improvement initiatives as needed. The Department made great strides in several areas directly relating to patient safety and service. Key improvements included:

- The Nuclear Medicine/Nuclear Cardiology/PET Section developed and implemented policies to bring radiopharmaceutical preparation in line with USP 797 regulations and JCAHO medication management standards. The policies require specific training and education initiatives with annual competency evaluation and daily environment inspection.

- CT and MRI developed and implemented policies to align contrast administration with JCAHO medication management standards and Leapfrog Survey requirements. Pharmacy was actively involved in the development of the policies. The policies increase the safety of the administration of contrast with regard to screening for reaction risk and nephrotoxicity and include mandatory MRI safety screening for implanted metal objects.

- CT also worked collaboratively with the Emergency Department (ED) to reduce the exam turnaround time for ED patients. The turnaround time was reduced by 45% and efforts are ongoing to further reduce this result.
Physician projects were both Departmental and section driven, to provide both a broad evaluation of fundamental parameters for all clinical Faculty as well as section-specific projects. At the Departmental level, installation of a new voice dictation system, coupled with significant improvements in PACS functionality resulted in a reduction in report turnaround time from 24 to 15 hours. During prime working hours, completed exams are often reviewed with finalization of reports in less than one hour. Migration of the Radiology peer review system to a PACS-based function allowed physicians to enter and retrieve data efficiently, and an electronic database provided material for comparison with national norms.

At the section level, specific projects included:

- Abdominal Imaging: Sources of Diagnostic Error Utilizing a PACS-based Peer Review System. With an ultimate goal of improving radiologist performance and patient care, the Section initiated a two year project to analyze errors recognized as part of the Department’s peer review program. Errors considered significant are reviewed during a meeting of all Section members, and categorized by potential cause of inaccuracy.

- Breast Imaging: Integration of the Digital Enterprise for Breast Imaging. The Section has worked in conjunction with the Information Technology group on a two year project to devise software solutions to decrease patient wait time, decrease technologist exam time, improve file room personnel work flow, reduce physician report time, and develop a database to ensure the timeliness and quality of patient care.

- Thoracic Imaging: Frequency and Nature of Errors in Radiological Reports Associated with Voice Recognition. Section members reviewed chest x-ray and chest CT reports for significant errors prior to and after the institution of a voice dictation system. A negligible error rate using conventional dictation and transcription increased to 24% of CT and 10% of chest x-ray reports immediately after conversion to a voice system. By report review and section discussion, a significant reduction in errors was achieved on initial follow up sampling.

- Vascular and Interventional Radiology: Detection and Treatment of Peripheral Vascular Disease in Hemodialysis Patients. The Section, recognizing the strong association of peripheral arterial disease (PAD) and severe renal disease, screened hemodialysis patients without known PAD by using noninvasive testing. Nearly 25% of patients were discovered to have significant disease, not previously identified in 90%. These patients with PAD were then treated with intervention or medical therapy, possibly avoiding significant future complications.

- Musculoskeletal Imaging: Analysis of the Adult Radiographic Skeletal Survey Examination at the University of Chicago. This project found that the number of skeletal radiographs obtained as part of a skeletal survey for malignancy could be reduced without diminishing clinical results. This decreased technologist time by 14% per examination, with an associated decrease in radiation dose to the patient.

- Pediatric Imaging: Hand Hygiene in Fluoroscopic Procedures before and after an Educational Intervention. In accordance with the National Patient Safety Goals, the Section instituted monitoring of hand washing adequacy by World Health Organization criteria prior to patient interaction. A goal of 100% compliance was achieved after repetitive education, although it was noted that repeated monitoring and intervention is required for success.

- Neuroradiology: Improving Temporal Bone CT Evaluation. Concern with variation in temporal bone CT imaging parameters, post processing and appropriate reconstruction from raw data led to standardization of techniques, educational efforts geared to the technologists and formulation of new protocols that were machine specific. These interventions significantly improved the quality of examinations, including 100% compliance with the new outpatient protocols.

- Nuclear Medicine: Improving Detection of the Sentinel Lymph Nodes in Breast Lymphoscintigraphy. This project demonstrated a statistically significant improvement in sentinel lymph node detection for operative guidance of patients with breast cancer, by varying the dosage of the radionuclide Tc-99m Sulfur Colloid.
The 2008 academic year was a year of programmatic expansion for the Section of Abdominal Imaging including diagnostic clinical techniques, research initiatives, resident and medical student education and quality assurance. Clinically, the Section added prostate MR imaging and spectroscopy for suspected or proven prostate cancer, under the guidance of Drs. Aytekin Oto and Michael Vannier as well as expanded programs in MR enterography and diffusion imaging. CT protocols were honed to remain cutting edge, with an emphasis on providing clinically relevant information with a minimum of radiation exposure to the patient. Virtual Colonography, long pioneered by Dr. Abraham Dachman, expanded as a clinical tool, both for colon screening and problem solving. Pediatric and adult ultrasound were combined under a single administrative structure with sharing of personnel to improve flexibility in patient scheduling and sonographer availability. To accomplish this, a “cross-training” program for the technical staff was successfully implemented and completed by all personnel. Improvements in the Department’s picture archiving and communication system (PACS) and full implementation of a voice dictation system under the leadership of Section member Paul Chang, MD, significantly decreased exam reporting time and provided direct electronic reporting to the Emergency Department.

From 1976 to 1994, Professor Beck was Chief of the Section of Radiological Sciences. In 1977 he was named Director of the University of Chicago’s Franklin McLean Memorial Research Institute, which replaced the Argonne Cancer Research Hospital. He helped to acquire a PET scanner and an MRI system, and to develop ways to improve the display of PET, MRI other scans. In 1986 he founded and became Director of the Center for Imaging Science, designed to pull together the many disciplines at the University and Argonne National Laboratory that rely on all sorts of imaging tools and methods.

Professor Beck is survived by his wife, Ariadne, of Indian Head Park, and two sisters, Mary Ann Beck and Dorothy Corbell of San Angelo, Texas.
MD, had a successful year with completion of the program by Dr. Kirti Kulkarni, who excelled clinically and completed significant research projects, both within the Section and in conjunction with the Section of Breast Imaging. Dr. Kulkarni joined the Department as a member of both sections in July of this year. Her broad based expertise will further enhance the clinical, teaching and research capabilities of the Section.

The Section has continued to be an active participant in the Radiology Departmental quality assurance program. Taking advantage of the information technology expertise of Dr. Paul Chang and University of Chicago Medical Center personnel, the biopsy results tracking system, a PACS-based function, has been utilized to compare invasive procedure efficacy with national standards and historical performance. As a major project, the Section is currently evaluating sources of diagnostic error, utilizing our PACS-based peer review system, with the ultimate goal of improving radiologist performance and patient care. Both of these initiatives have been accepted as scientific presentations at the Radiological Society of North America meeting in November, 2008.

Abdominal Imaging faculty continue to excel in service to the imaging community and recognition by their peers. Dr. Richard Baron, Departmental Chair, was Chair of the Educational Exhibits Committee of the Radiological Society of North America (RSNA) and president of the Society of GI Radiology. He was awarded an Honorary Fellowship in the European Society of Gastrointestinal and Abdominal Radiology, and made an Honorary Member of La Sociedad Argentina de Radiologia and the Federacion Argentina de Asociaciones de Radiologia, Diagnostico por Imagenes y Terapia Radiante.

Dr. David Paushter, Section Head and Vice Chair of Operations, was named as Chair of the Clinical Standards Committee of the American Institute of Ultrasound in Medicine (AIUM) and liaison between the AIUM and the American College of Radiology (ACR). Dr. Paushter was also named a Fellow of the ACR in a ceremony in May of this year.

Dr. Abraham Dachman served on multiple committees for the ACR, the RSNA, the ARRS and the SGR, and continued with significant appointments in conjunction with his work on virtual colonography for the National Institutes of Health (NIH). He also served as presiding Officer for Scientific Sessions at the 2007 RSNA annual meeting. Dr. Dachman’s pioneering work in virtual colonography has provided a basis for multiple funded grants, including NIH/NCI and ACRIN trials. He has just completed a seven year tenure as Managing Editor of the Radiology book of the eMedicine Project. Dr. Dachman, through his research on virtual colonography, was involved in eight funded projects during the academic year.

Dr. Michael Vannier, Vice Chair of Research, was a member of the Advanced Technology Center Steering Committee, Radiation Research Program of the National Cancer Institute. He also served as Chairman for an NIH site review, and participated as an external advisor to multiple health care systems. Dr. Aytek Oto, Director of Body MR, was involved in three newly funded grants during the past year.

Dr. Paul Chang provided service to multiple societies in key roles, including the Society for Computer Applications in Radiology, the Association of University Radiologists, the National Library of Medicine of the NIH and the RSNA. He received the Association of University Radiologists (AUR) Herbert Stauffer award for best clinical paper in 2007. He has continued to provide service to SIIM/SCAR in multiple capacities, and plays a pivotal role in the development of radiology informatics for the RSNA.

All section members were actively involved as manuscript reviewers for such journals as Radiology, the American Journal of Roentgenology, Radiographics, the Journal of Computer Assisted Tomography, and Computerized Medical Imaging and Graphics. Dr. Michael Vannier served as Editor-in-Chief of the Sagittal 3-D CT image of the Thoracic Aorta and Great Vessels

Sagittal CT Image of the Chest, Abdomen and Pelvis Demonstrating Enlarged Lymph Nodes
resulted in an ever-growing need for multimodality assessment of imaging findings. The complexity/difficulty of interventional procedures has increased significantly in recent years, with many more patients undergoing axillary lymph node sampling, multiple biopsies, and multiple wires placed at needle localization. Current faculty includes Hiroyuke Abe, MD, Gillian Newstead, MD, Robert A Schmidt, MD, Charlene Sennett, MD, and Michael Vannier, MD, Kirti Kulkarni, MD, joined us in July after completing two fellowships, one in breast imaging and the other in abdominal imaging.

Our comprehensive Continuous Quality Improvement project this past year was aimed at improving workflow for patients, physicians, technologists, administrative assistants and file personnel. Breast faculty members have spent a great deal of time this past year working with an IT team group, led by Dr Paul Chang. The goal has been to develop a workflow program which will integrate the specific Breast Imaging Center needs, for viewing, reporting and auditing, into the hospital and radiology IT networks. Although this project is not yet completed and is still in the early phase of implementation, we have received continuous comprehensive support from the IT section during the past year. We look forward to an all-digital section with optimized workflow in the future.

Our clinical research pursuits encompass investigation of multimodality diagnostic and therapeutic techniques for breast cancer detection and evaluation in both human and animal models. The major sectional research interests this past year have included both clinical investigative models conducted by faculty, fellows and residents, and translational research involving close collaboration with Informatics to Enhance Radiology Relevance and Value” at the President’s Address and Opening Session. Dr. Baron and Dr. Dachman served as Exhibit and Scientific Chairs respectively for the meeting. A Certificate of Merit from the RSNA was presented to Dr. Aytekin Oto and his co-presenters for a web-based broadcast during the meeting.

As the Section looks forward to the 2009 academic year, it is expected that the current levels of clinical, educational and academic achievement will continue to escalate. New challenges will include helping to define the roles of 256 slice CT and 3T MR in clinical practice, and continuing the refinement of our educational programs. Academic activities including funded grants and scientific publications will further mature as a result of mentoring and faculty growth within the Section. Our involvement in novel methods of measuring and reporting disease will also contribute to continued clinical excellence.

Breast Imaging

The Section of Breast Imaging (left to right): Dr. Gillian Newstead, Dr. Robert Schmidt, Dr. Charlene Sennett, Dr. Michael Vannier, Dr. Akiko Shimauchi (Clinical Fellow), Dr. Susan Sung (Clinical Fellow), Dr. Hiroyuki Abe.

The mission of the Section of Breast Imaging is to provide excellent comprehensive screening and diagnostic breast health care for our patients. We provide a full spectrum of mammographic, ultrasound, magnetic resonance imaging, and breast interventional procedures. The screening clinic provides service to the surrounding community and we are a referral center for the evaluation of patients with difficult diagnostic problems and those with newly diagnosed breast cancer. We conduct a busy high-risk screening program using mammography, ultrasound and MRI, in collaboration with Dr. F. Olopade in the department of Medicine. We work daily with the breast medical and radiation oncologists, surgeons and pathologists, and participate actively in a weekly management interdisciplinary conference. We have experienced increasing numbers of outside referred patients, sent to Breast Clinic for radiological and surgical consultation, and this has resulted in an ever-growing need for multimodality assessment of imaging findings. The complexity/difficulty of interventional procedures has increased significantly in recent years, with many more patients undergoing axillary lymph node sampling, multiple biopsies, and multiple wires placed at needle localization. Current faculty includes Hiroyuke Abe, MD, Gillian Newstead, MD, Robert A Schmidt, MD, Charlene Sennett, MD, and Michael Vannier, MD, Kirti Kulkarni, MD, joined us in July after completing two fellowships, one in breast imaging and the other in abdominal imaging.

Our comprehensive Continuous Quality Improvement project this past year was aimed at improving workflow for patients, physicians, technologists, administrative assistants and file personnel. Breast faculty members have spent a great deal of time this past year working with an IT team group, led by Dr Paul Chang. The goal has been to develop a workflow program which will integrate the specific Breast Imaging Center needs, for viewing, reporting and auditing, into the hospital and radiology IT networks. Although this project is not yet completed and is still in the early phase of implementation, we have received continuous comprehensive support from the IT section during the past year. We look forward to an all-digital section with optimized workflow in the future.

Our clinical research pursuits encompass investigation of multimodality diagnostic and therapeutic techniques for breast cancer detection and evaluation in both human and animal models. The major sectional research interests this past year have included both clinical investigative models conducted by faculty, fellows and residents, and translational research involving close collaboration with Informatics to Enhance Radiology Relevance and Value” at the President’s Address and Opening Session. Dr. Baron and Dr. Dachman served as Exhibit and Scientific Chairs respectively for the meeting. A Certificate of Merit from the RSNA was presented to Dr. Aytekin Oto and his co-presenters for a web-based broadcast during the meeting.

As the Section looks forward to the 2009 academic year, it is expected that the current levels of clinical, educational and academic achievement will continue to escalate. New challenges will include helping to define the roles of 256 slice CT and 3T MR in clinical practice, and continuing the refinement of our educational programs. Academic activities including funded grants and scientific publications will further mature as a result of mentoring and faculty growth within the Section. Our involvement in novel methods of measuring and reporting disease will also contribute to continued clinical excellence.

Breast Imaging

The Section of Breast Imaging (left to right): Dr. Gillian Newstead, Dr. Robert Schmidt, Dr. Charlene Sennett, Dr. Michael Vannier, Dr. Akiko Shimauchi (Clinical Fellow), Dr. Susan Sung (Clinical Fellow), Dr. Hiroyuki Abe.
our physicist colleagues. Broadly writ, the main topics of interest continue to be: multimodality assessment of lymph nodes for detection of metastases, development of new breast MR protocols for improved cancer detection and analysis, functional assessment of normal breast tissue, computer-aided visualization and analysis (CAVA) of breast lesions and the study of DCIS and high-risk lesions using MRI and mouse models.

A major research initiative, under the leadership of Dr. Olufunmilayo Olopade, has resulted in funding of an NIH Specialized Programs of Research Excellence (SPORE), in Breast Cancer. This award of $11.5 million over five years will enable us to implement a multifaceted strategy of translational research designed to reduce the death and disability caused by breast cancer worldwide. This effort focuses on developing genetic-based approaches to the treatment, prevention, and detection of breast cancers in women who are at risk of developing an aggressive form of the malignancy at a young age.

Sunny Jansen, a physics graduate student, who works closely with faculty and clinical fellows, presented her prize-winning paper on DCEMR findings in benign and malignant breast lesions, at RSNA 2007.

We have received grant funding from a variety of organizations: NIH, industry and philanthropic sources, have presented 24 scientific papers at national and international meetings, and have published 9 manuscripts.

The Section of Musculoskeletal Imaging: Dr. Scott Stacy and Dr. Larry Dixon. Not pictured: Dr. Christopher Straus.

The Musculoskeletal Radiology Section continues to provide state-of-the-art multimodality imaging and image-guided interventional procedures for patients of the University of Chicago Medical Center. The busy Orthopedic Oncology Service has long been an example of a team-approach to patient care, and Drs. Dixon and Stacy provide comprehensive services as part of the University of Chicago Musculoskeletal Oncology Group. The Musculoskeletal Radiology Section also works closely with the Section of Sports Medicine to offer services to all athletes (including the Chicago Blackhawks professional hockey team), as well as the Section of Rheumatology to diagnose complex disorders of joints. With the introduction of the Department’s speech recognition system, report turnaround time has decreased dramatically, and during the workday clinicians will often have access to the dictated reports before they see their patients.

The Section works closely with the imaging technologists to provide excellence in care to all patients. As part of an ongoing quality improvement initiative, the Section, with the help of the MRI technologists, evaluated factors that contributed to the overall duration of routine knee magnetic resonance imaging studies in an effort to increase patient comfort and throughput. This allowed the section to significantly shorten the standard knee MRI protocol while adding a new dedicated pulse sequence for exquisite depiction of articular cartilage defects. The project

35 year old, post right axillary node biopsy: positive for adenocarcinoma. Mammography normal. MRI shows a breast cancer.
“3D” reformatted CT image of shoulder shows Bankart fracture (arrow) of glenoid

Transverse CT image of femur shows patient undergoing radiofrequency ablation of eosinophilic granuloma.

was a highlight of the 2007 Quality Fair sponsored by the Center for Quality, and was one of three prize-winning exhibits for the entire Medical Center. This year’s quality improvement project involves a detailed evaluation of the radiographic skeletal survey for staging of patients with multiple myeloma in an attempt to decrease examination time and radiation dose.

Dr. Stacy was promoted to Associate Professor of Radiology in July of 2007 and assumed the role of Section Chief in September, a position that Dr. Dixon held for 15 years while delivering clinical service highly respected by both patients and clinicians. Dr. Dixon continued in his role as Director of the Musculoskeletal Imaging Fellowship. Dr. Saad Naseer, the 2007-2008 Musculoskeletal Imaging Fellow, followed in Dr. Dixon’s footsteps as a favorite educator among the residents. Both Dr. Naseer and Dr. Stacy received awards for their efforts in preparing the senior residents for the oral Board Certification Examination. Dr. Naseer has accepted a position at St. Johns Hospital, in Springfield, Illinois, affiliated with Southern Illinois University Medical School, and will begin July 1st as an Assistant Professor.

Academically, the Section maintains a national presence with scientific and educational presentations at the annual meetings of the American Roentgen Ray Society and the Society of Skeletal Radiology. Dr. Stacy and Dr. Rodney Corby (senior radiology resident and future musculoskeletal radiologist) received the Silver Medal from the ARRS for their educational exhibit “Benign and malignant masses of high signal intensity on T2-weighted MRI studies of the knee: An interactive tutorial” at the Society’s annual meeting in Washington, DC.

Medical student education continues to flourish, with dedicated musculoskeletal imaging lectures given during the Gross Anatomy and Human Morphology courses for the first-year students, as well as an arthritis review for the second-year students as part of their Physical Diagnosis Course. The musculoskeletal imaging rotation continues to be popular with fourth-year medical students, especially those pursuing residencies in radiology and orthopaedics.

Neuroradiology

Neuroradiology

The Section of Neuroradiology (left to right): Dr. Cheng Hong (Clinical Fellow), Dr. Fang Zhu (Clinical Fellow), Dr. Vivek Sehgal, Dr. Delilah Burrowes, Dr. Jordan Rosenblum, Dr. Saeid Mojtahedi.
He will work with our colleagues in Neurology and which he worked as a faculty member at Michigan.

Dr. Ansari, who is currently at the University of Michigan, will join our section as a Neurointerventionalist in late 2008. Dr. Ansari trained at the University of Michigan and then at The University of Michigan after which he worked as a faculty member at Michigan. He will work with our colleagues in Neurology and molecular imaging research which he plans to continue in collaboration with Dr. Brian Roman.

We had two fellows the past year. Cheng Hong, MD, PhD, began his clinical fellowship in August of 2007. Dr. Hong trained in China and completed his PhD work in Germany. He has been involved in radiology research for the past seven years. He has made a very smooth transition back into clinical medicine and has begun two interesting research projects in the evaluation of carotid artery plaque and the association with intra-cranial disease. Dr. Hong was awarded a 2008 Roentgen Resident/Fellow Research Award from the RSNA for his efforts.

Fang Zhu, MD, PhD, joined us in August as a research associate. She immediately became involved in a number of research projects involving quantification of white matter disease, perfusion and DTI imaging in tumors, and DTI imaging in the evaluation of white matter disease. She received partial funding for her project in DTI imaging in white matter disease. She will begin clinical training in 2008.

The past year has been an exciting one for the section of Neuroradiology. At year end we have successfully recruited three new faculty members and two fellows. We have new programs in tumor imaging and white matter disease. We have made plans for revitalization of our pediatric neuroradiology program as well as our Head and Neck imaging, and we are beginning the planning process for neuro-interventional radiology when Dr. Ansari joins us. Research activities have begun in tumor imaging with several abstracts submitted in this year.

The Section has undergone major changes within the last academic year. At year end we have successfully recruited three new faculty members and as a result, there have been exciting new changes in clinical expertise, research interests and new clinical programs. During the past year we have begun actively imaging brain tumors with MR perfusion and DTI tractography. These techniques are now an integral part of several research projects, and are performed routinely in appropriate patients. Planning is underway to begin fMRI in clinical patients and to restore full neuro-interventional services in late 2008. Faculty recruits include:

Dr. Delilah Burrowes joined us from Children’s Memorial in Chicago. Dr. Burrowes is sub-specialty trained in both adult and pediatric neuro-radiology with special expertise in MR spectroscopy. This is our first formally trained pediatric neuroradiologist and her contributions have already generated a great deal of enthusiasm from pediatric surgery, neurology and neuro-oncology.

Dr. Vivek Sehgal also joined the section. Dr. Sehgal trained here at the University of Chicago, completing a two year fellowship followed by several years as a junior faculty member before moving to Wayne State University in Detroit. In Detroit, Dr. Sehgal was actively involved in running the MRI section and gained expertise in fMRI as well as spectroscopy and advanced imaging techniques. He was involved in a number of research projects involving susceptibility weighted imaging, a novel technique that has been pioneered at Wayne State.

Dr. Sameer Ansari, who is currently at the University of Michigan, will join our section as a Neurointerventionalist in late 2008. Dr. Ansari trained at the University of Illinois and then at The University of Michigan after which he worked as a faculty member at Michigan. He will work with our colleagues in Neurology and...
exciting area. Active collaboration is underway with our neuro-oncologists, neurologists interested in white matter disease, and with our neurosurgery colleagues in a number of different projects.

Teaching in the section has expanded via the faculty recruits with new pediatric radiology conferences, follow-up conference and teaching conferences on advanced imaging techniques. We are also able to actively participate in a number of inter-disciplinary conferences with better staffing levels. We have two fellows with one completing his first year of clinical fellowship and the second completing her first year in the lab, and now beginning her clinical training.

**Nuclear Medicine**

The past year the Section of Nuclear Medicine has seen significant structural improvements, completing a major renovation of its general nuclear clinic, moving into a beautiful, brand-new facility. The four new gamma camera rooms with the latest imaging equipment, technologist work room, physician reading room, patient interview and injection rooms, and coordinator’s and manager’s offices comprise a terrific infrastructure for performing state-of-the-art nuclear imaging and therapy while maximizing patient comfort. The renovation coincided with the new United States Pharmacopeia (USP) 797 regulation mandating that radiopharmaceuticals be treated with the same sterile rigor as all prepared pharmaceuticals. As a result, our new radiopharmacy was the first and still one of the very few in the country to be USP 797 compliant, with our strict adherence to sterile procedures in a sterile environment. We look forward to the results of similar renovations, just commenced, in cardiac nuclear medicine which we expect to complete during the coming year.

In our continued efforts to promote clinical quality for patients and referring clinicians alike, the Section undertook a quality improvement program aimed at optimizing sentinel node detection in patients newly diagnosed with breast cancer and undergoing a lymphoscintigraphy prior to surgical axillary dissection. The goal was to find the ideal volume and dose of radiotracer administered to maximize conspicuity of the sentinel lymph node for the surgeon while minimizing radiation to the patient. The results have thrilled our referring surgical clinicians while significantly improving patient care.

Sectional academic output continues to be prodigious and acclaimed in the scientific and lay communities alike. Research endeavors are quite varied, ranging from basic imaging science to clinical whole body and brain studies with FDG-PET/CT. Our work on computer aided diagnosis (CAD) and temporal subtraction in bone scintigraphy resulted in a patent which we are working to translate into an intelligent workstation for use by medical centers across the world. Our NIH funded study utilizing brain PET to assess the effects of sleep deprivation on obesity was recently featured on CBS’s 60 Minutes, capturing the public’s imagination. Additional work collaborating with our clinical colleagues includes a novel technique in evaluating inflammatory bowel disease utilizing whole body FDG-PET/CT to assess for disease activity and response.
to therapy. And we are increasingly involved in oncology trials utilizing PET/CT to stage and monitor new therapies for a host of tumor types.

Our faculty continues to excel individually and as a unit. Dr. Pu, long certified in nuclear medicine recently added to his credentials, attaining board certification in radiology. He now joins section chief Dr. Appelbaum in forming one of the very few academic nuclear departments where all members are certified by both the ABNM and ABR. While rare, this section-wide dual training is increasingly important as molecular and anatomic imaging continue to merge, as exemplified by PET/CT and SPECT/CT. Dr. Appelbaum remains an active member on national educational committees at both the American Board of Radiology and the Society of Nuclear Medicine. He is also a frequent invited lecturer at both the regional and national levels. Our experienced physicist, Dr. O’Brien Penney, who recently completed his term as national secretary for the Computer and Instrumentation Council of the SNM, keeps the clinic operating at a very high level while providing invaluable research and teaching support to the Section and University as a whole.

Education remains a critical mission for the Section which is an active participant at the medical student, resident and doctoral candidate levels. The noon conference program has been reformatted into a standardized lecture format, while resident case-taking approaches are refined at daily board-size sessions and during level-specific end of rotation exams. Dr. Straus has been leading the Department’s redesign of medical student education, which includes new lectures exposing students’ to nuclear and molecular concepts at an early level.

And so, as we move into our beautiful new facility, the Section is stronger and more energized than ever before. The structural improvements will provide an incredible platform as they continue to build their high-quality patient care, research, and educational initiatives to even greater heights in the coming year.

Pediatric Imaging

The Section of Pediatric Imaging (left to right): Dr. Kate Feinstein, Dr. Mario Zaritzky, Dr. David Yousefzadeh.

The Section of Pediatric Radiology remains dedicated to the care of neighborhood children as well as those from around the world. Our patients have very complex medical conditions, mirroring our referral base. We care for many extremely premature infants, children with cancers, children with chronic diseases, and children who have suffered major physical traumas. All of the staff, comprising technologists, nurses, child-life experts, and clinic coordinators, are dedicated pediatric care professionals who are instrumental in the efficient, safe, and sympathetic function of the radiology department. The sedation team, lead by Pediatric Intensive Care physicians, is based in the pediatric radiology department. The sedation team works closely with the radiology department to ensure that children who need to stay immobile for long magnetic resonance, CT, or nuclear medicine exams are able to have their tests performed.

The Section uses web-based modules as the backbone for its curriculum. The education of radiology residents, pediatric residents and medical students has been enhanced by this methodology. The curriculum is supplemented by textbooks, journal articles, lectures and clinical conferences. The radiology residents, under the guidance of the faculty, participate in several interdisciplinary conferences: pediatric tumor board, pediatric surgery-pathology conference, and pediatric gastroenterology conference. An essential part of the curriculum is learning how to care for all of our patients, from the extremely low gestational age neonates who weigh less than one pound to our young adult patients who are making the transition from pediatrician to internist.

The residents work with the faculty in order to become competent at the hands-on examinations such as fluoroscopy and ultrasonography. They also learn the use and development of low-dose CT techniques as another principal part of the curriculum. Publications and
presentations for the past academic year include: variability of observer assessment of brain sonograms, sonographic and Doppler evaluation of growing cartilage, the use of magnets in the treatment of esophageal atresia, and sonographic evaluation of musculoskeletal infections.

Color Doppler ultrasound of two year old boy’s swollen ankle after IV removal shows the Yin-Yang sign. The Yin-Yang sign is due to turbulent blood flow in an arterial pseudoaneurysm.

Color Doppler ultrasound with vascular tracing confirms the arterial nature of the blood flow. The early diagnosis of pseudoaneurysm allowed prompt surgical resection to prevent life-threatening complications.

**Thoracic Imaging**

The Section has maintained a high level of clinical service in spite of constantly increasing volume of CT scans, and steady volume of chest radiography. With the implementation of voice recognition dictation with Commissure in October 2007, report turnaround time decreased dramatically, while productivity was only minimally impaired during the initial implementation.

Our Section has been strengthened in the past year by the addition of Dr. Chris Straus, and by the contributions of Dr. Steve Zangan and Dr. Brent Greenberg.

These new part time members of the Section have provided greater flexibility with staffing, and have brought valuable skill sets in teaching and in other areas of radiology, which complement the existing group.

We remain at the cutting edge of new technology with planned installation of a new dual energy chest radiography unit, as well as a flat panel detector instant readout portable radiography unit. Our clinical experience with dual energy imaging is summarized in the current issue of *The Journal of Thoracic Imaging*, for which Dr. MacMahon is the guest editor.

In CT we have exploited the potential of our 64-slice scanners by routinely performing comprehensive sets of image reconstructions, and by archiving source images on all cases as of January 2008.

The Chest Section has continued its successful collaboration with the Radiological Sciences Section during the past year. The current challenge is to involve younger faculty and residents in research, and to maintain the present level of productivity in the face of increasing pressure of clinical work and limited staffing.
The Vascular and Interventional Radiology Section continued to thrive in 2007-2008 despite many challenges. Our current interventional radiology suites and combined holding and clinic area have enabled us to meet the ever expanding demand for services. We have been able to provide prompt service with most procedural requests addressed within 24 hours. Our role in evaluation and management continues to expand and we continue to provide the entire gamut of diagnostic and therapeutic Vascular and Interventional Radiology procedures. We have added microwave ablation and drug eluting beads to our local regional cancer therapy program. In addition, we have acquired equipment necessary to initiate a varicose vein clinic spearheaded by Drs. Thuong Van Ha and Steve Zangan.

As a continuing quality improvement program, we initiated an outreach and screening program for nephrology patients with untreated peripheral vascular disease. We found that 25% of our dialysis patients had undiagnosed and untreated peripheral arterial disease. All of these patients are being treated and followed longitudinally in our clinic.

Academically, our Section remains active on a national and international level. Dr. Brian Funaki continues his role as editor-in-chief of Seminars in Interventional Radiology and serves on the editorial board of Radiology Case Reports and the Journal of Vascular and Interventional Radiology. He is a fellow in the Society of Interventional Radiology and currently co-chairs the Volunteers Committee in the society. He is the associate program director of the 2008 American Roentgen Ray Society annual meeting as well as organizer for numerous courses at this meeting. Dr. Funaki was promoted to the rank of Professor of Radiology and recently accepted the position of Chairman of the American College of Radiology’s Appropriateness Criteria Expert Panel on Interventional Radiology. All full-time faculty lectured at all major radiology meetings including SIR, RSNA,ARRS, and CIRSE. The Teaching Atlas of Vascular and Interventional Radiology by Drs. Brian Funaki, Jonathan Lorenz and Thuong Van Ha was published by Thieme. A total of 25 peer-reviewed and invited articles were published by section members during the academic year.

Much of the Section’s efforts are dedicated to training residents and fellows. Under the supervision of fellowship director, Dr. Lorenz, we trained two fellows in our one year ACGME accredited fellowship and have continued to refine an educational curriculum for residents and fellows. Both fellows from the past year pursued academic careers and accepted assistant professor positions: Dr. Steve Zangan joined our faculty and Dr. Grace Knuttinen joined the faculty of the University of Illinois where she also serves as resident program director.

In summary, the Vascular and Interventional Radiology Section maintains excellence in its clinical, teaching and academic endeavors.
Advanced Cone-Beam CT
Graduate students Junguo Bian, Sengryong Cho, Xiao Han, and Dan Xia, along with Emil Sidky, PhD, Michael Vannier, MD, Richard Baron, MD, and Xiaochuan Pan, PhD, are performing research on advanced CT imaging. CT remains one of the dominant medical imaging techniques. In particular, the research on helical cone-beam CT has been extremely active because of its high volume-scanning speed and temporal resolution. Indeed, helical cone-beam CT would allow for new imaging protocols that were not possible with conventional CT. The researchers have made significant breakthroughs in CT research and enjoy a leading status in this area. Specifically, they have developed computationally efficient and numerically stable algorithms for obtaining images in helical cone-beam CT, have designed innovative scanning strategies and algorithms for obtaining images with improved resolution properties, and have developed the new strategy and algorithms for reconstructing images within regions of interest (ROIs) from much reduced data. Most importantly, they have developed and refined new concepts and algorithms that would allow the design of innovative imaging protocols that may have significant clinical implications, e.g., for breast imaging, liver imaging, and cardiac imaging. One of the important advances made in the past year was the development of algorithms for image reconstruction from highly incomplete data, which are expected to find significant applications to a wide variety of imaging problems in medicine, security scan, and other areas.

System and Algorithm Development of Micro-CT and Its Applications
Graduate students Junguo Bian, Sengryong Cho, and Xiao Han, along with Xiaochuan Pan, PhD, are developing micro-CT and its applications to small animal imaging. Micro-CT plays an important role in animal and molecular imaging. In the past year, in collaboration with Charles Pelizzari, PhD, and Chin-Tu Chen, PhD, they have developed the first micro-CT system for animal imaging on the campus. This system can provide 3D images with isotropic resolution at 30µm to 50µm. They have been using this system to perform imaging studies of lung cancer, bone cancer, and vascular vessels in small animals from various laboratories in the BSD. The researchers are also using this system to perform a wide variety of studies aiming at understanding the physical properties of the system and reconstruction algorithms. They expect that a large number of studies on small animal imaging and on imaging physics and algorithms will be conducted on this system and that a large amount of data and results will be generated, which can form the basis for the development of advanced micro-CT with the capability of performing innovative scanning tasks. In the past year, more than 150 mice have been scanned using their laboratory-made micro-CT.

Improving Image Quality in Low-Dose and Low-Contrast CT
Patrick La Riviere, PhD, and graduate student Phillip Vargas are working with Michael Vannier, MD, and researchers at Philips Medical Systems to develop computationally efficient sinogram-domain approaches that help improve image quality in low-dose and non-contrast CT exams. Continuing technological innovations have spurred growth in the number of CT exams performed annually, which has prompted concern over the associated rise in CT-related radiation dose to the population. The ability to reduce CT dose without sacrificing image quality would have significant beneficial public-health consequences. This is especially pertinent given that widespread use of CT in screening for lung and colon cancer is currently being considered. The data measured in a low-dose scan is necessarily noisier than data measured in a standard scan, and this can lead to an overall mottled appearance in the images as well as to noise-induced streak artifacts than can obscure subtle lesions. In the past few years, this group has developed a novel strategy for CT data processing that entails application of a statistically principled penalized likelihood estimation of the ideal, low-noise line integrals needed for image reconstruction from the noisy degraded transmission measurements. The preliminary results suggest that dose reductions of 30% or more might be achievable relative to current clinical standard-exposure scans, and even larger dose reductions may be possible for the low-dose screening scans.
**Positron Emission Tomography**

**Ultra-Sensitive MicroPET Scanner**

Graduate student Yun Dong, MS, Qingguo Xie, PhD, Chin-Tu Chen, PhD, and Chien-Min Kao, PhD, are developing a microPET prototype scanner that provides ultra-high sensitivity by using two large-area HRRT (High Resolution Research Tomograph) detector heads in a compact geometry (Figure 5) and employing advanced image reconstruction algorithms. At activity levels of interest for rodent imaging, the effective sensitivity of the prototype is about an order of magnitude better than most other existing microPET scanners.

The microPET prototype employs two HRRT detectors (from Siemens) in a compact configuration to provide ~30% central sensitivity. In comparison, the sensitivity of most existing microPET systems is <5%.

(Figure 6) and the image resolution is about 1.2 mm (Figure 7a). This high sensitivity can reduce radiation dose and the scan time, improve the temporal resolution in dynamic studies, and follow the spatiotemporal variations of minute amounts of radiotracers longer than previously possible. The prototype is being employed in biomedical research studies (Figure 7b). FDG rat images show that the prototype provides adequate image resolution for imaging the heart. In a stroke research, increased brain activity associated with a forelimb-reaching task is also detected (Figure 7c).

**Digital PET Data-Acquisition (DAQ) Architecture**

NIH postdoc fellow Heejong Kim, PhD, Research Associate Qingguo Xie, PhD, Chin-Tu Chen, PhD, and Chien-Min Kao, PhD, are investigating a novel multi-threshold method for digitizing PET event waveforms to enable the application of digital signal processing to the resulting samples for extracting event information that are relevant in PET imaging, including the event time, event energy, and the decay constant of the scintillator (Figure 8). When applied to LSO/PMT detectors, the current prototype (having 4 thresholds) can yield ~350ps resolution in coincidence timing, ~18% resolution in energy, and ~20% resolution in the decay-time constant. This new technology removes analog components and can bring digital revolution to PET electronics, possibly leading to improved performance, reduced cost, and smoother upgrade path. This is a collaborative research effort with Professor Henry Frisch of the Enrico Fermi Institute, the University of Chicago and Dr. William Moses of the Lawrence Berkeley Laboratory.

(a) A novel multi-threshold method for digitizing a PET event waveform with respect pre-defined amplitude thresholds; b) a prototype implementation of the method that consists of a 4-channel discriminator board and a TDC; c) an event waveform generated by an LSO/PMT unit (black curve), the samples generated by the prototype (blue circles), and the fitted pulse shape from the samples (red curve).
**Time-of-Flight (TOF) PET Imaging**

Chien-Min Kao, PhD, has developed a new theory and a new class of image reconstruction algorithms for TOF-PET. The new theory reveals previously unrecognized benefits of TOF-PET imaging, and the new algorithms create new modes for TOF-PET imaging. Figure 9 shows a situation in which the new reconstruction algorithms can significantly reduce the negative effects of data noise associated with a hot structure to the quality of nearby structures of interest. The use of the new theory and algorithms can lead to new TOF-PET system designs.

![Figure 9](Image)

(Left) An image that contains two small structures within a region of interest (ROI) nearby a large, hot structure. Such situation can occur in prostate imaging in which the two small structures are the prostates and the large structure is the bladder; (Middle) Image generated by using the new TOF-PET reconstruction algorithm for the ROI; (Right) Image within the ROI obtained by using a conventional TOF-PET image reconstruction algorithm. The new reconstruction algorithm significantly improves the visualization and qualitative of the structures of interest.

**Single-Photon Emission Computed Tomography**

**Super-Resolution SPECT**

Visiting Scholar Ching-Han Hsu, PhD, from the Department of Biomedical Engineering and Environmental Sciences of the National Tsing-Hua University in Taiwan, Chien-Min Kao, PhD, and Chin-Tu Chen, PhD, are collaborating with Ling-Jian Meng, PhD, of the Department of Nuclear, Plasma, and Radiological Engineering of the University of Illinois at Urbana-Champaign to utilize electron-magnifying CCD (EMCCD) technology to build single-photon emission microscopes (SPEM) that can offer very high spatial resolution better than 100 microns. These super-resolution imaging devices present special research challenges in system calibration, image reconstruction, experimental protocol designs, etc., and also offer unique opportunities in imaging of brain and other immobilized organs or tissues to acquire super-resolution images unattainable previously. Together with Ming-Chi Shih, MD, PhD, they are also collaborating with Dr. Rodrigo Bressan of the Albert Einstein Institute in Brazil to design and build special high-resolution multi-pinhole collimators and the associated image reconstruction and analysis algorithms as well as software libraries. These special collimators will be used in conjunction with regular clinical SPECT imaging systems for animal imaging studies in investigation of brain and behavioral disorders.

**Applications of Imaging Techniques to Radiation Therapy**

Graduate students Sengryong Cho and Erik Pearson, and Xiaochuan Pan, PhD, are performing research on image-guide radiation therapy. Radiation therapy remains one of the most important procedures for treating cancer. The goal of conformal radiation therapy is to deliver a high radiation dose to the tumor volume, while minimizing the radiation exposure of healthy tissues that surround this volume. Therefore, treatment planning is a critical step for accurate and effective radiation therapy. Because treatment planning is conceptually related to a reverse process of SPECT imaging the insights and techniques attained in our research on SPECT can shed the light on the development of effective methods for accurate treatment planning in radiation therapy. In collaboration with Dr. Charles Pelizzari of the Department of Radiation and Cellular Oncology, they have been investigating and developing dose-efficient image guided treatment methods for detecting patient positioning errors in conformal radiation therapy treatments. Unlike previously proposed approaches, these methods will be based upon the theory of local tomography, and, consequently, will only utilize treatment radiation that passes through or very near the tumor volume to form the reconstructed image of the tumor volume. Also, this ROI imaging strategy provides an excellent opportunity for imaging the targeted tumor region with considerably reduced radiation dose.

**Applications of PET/SPECT/CT Imaging to Biomedical Research**

Graduate Student Yun Dong, Research Professional Christian Wiethold, PhD, Ming-Chi Shih, MD, PhD, Research Associate Qingguo Xie, PhD, Visiting Research Fellow Antonio Machado, MD, Chien-Min Kao, PhD, Patrick La Riviere, PhD, Xiaochuan Pan, PhD, and Chin-Tu Chen, PhD, have been collaborating with many faculty members in the Departments of Radiology, Radiation and Cellular Oncology, Medicine, Surgery, Pathology, Biochemistry and Molecular Biology, etc., on using CT, PET, and SPECT methodologies for biomedical research in a variety of applications. The topics range from investigation and characterization of new imaging probes including nanoparticles, imaging of animal models of breast, prostate, lung, bone, and other cancers, development of image-guided therapy strategies for radiation therapy, chemotherapy, and gene therapy, imaging for drug evaluation and development, investigation of cardiac and pulmonary functions under various healthy and diseased conditions, studies of brain function and imaging for brain and behavioral disorders, etc.
**MRI**

**New Florsheim Magnet**

Installation of the new Florsheim 9.4 Tesla MRI scanner was completed and the scanner is now producing extraordinary high resolution images. For example, Figure 10 compares scans of a mouse mammary gland obtained on the old scanner at 120 micron resolution with images from the new magnet acquired with 65 micron resolution. The new scanner shows DCIS in the mammary gland with impressive detail.

![Old magnet: 120 micro resolution](image1.png)

![New magnet: 65 micro resolution](image2.png)

**Figure 10**

**Studies of Early Breast/Mammary Cancer**

Sunny Jansen (a graduate student in Medical Physics) studied early cancer in the mouse and has produced exciting results. Ms. Jansen (with Dr. Tatanja Paunescu and Dr. Gayle Woloschak from Northwestern University) demonstrated that Omniscan – a low molecular weight MR contrast agent - enters mammary ducts containing DCIS (see Figure 11). This demonstrates that in clinical MRI, enhancement of DCIS post contrast injection is largely due to leakage of contrast agent molecules into ducts. By serially imaging mouse mammary glands over a period of 10 weeks, Ms. Jansen also demonstrated that not all DCIS in mice progresses to invasive cancer. Previously it was believed based on indirect evidence that DCIS is a ‘non-obligate’ precursor to breast cancer. But Ms. Jansen’s results provide the first direct support for this hypothesis. This is an important finding that will influence clinical treatment of DCIS, and drive the development of new MRI methods that can distinguish between DCIS that is likely to progress to invasive cancer and DCIS that will not progress and requires less aggressive treatment or ‘watchful waiting’.

**MRI Studies of Pre-cancerous Conditions in Mouse Prostate**

Sean Foxley used echo-planar spectroscopic MR imaging (EPSI) to evaluate prostate cancer and pre-cancerous conditions in a transgenic mouse line compared with conventional non-spectroscopic imaging techniques. Simian virus large T antigen transgenic male mice (n = 7, age = 34 ± 3.7 weeks) were imaged using EPSI, gradient echo, and spin echo pulse sequences. Water peak-height (PH) images produced from high spectral and spatial resolution (HiSS) datasets showed twice the mean signal-to-noise ratios (p < 0.001) and two to three times the contrast-to-noise ratio (p < 0.03) than conventional images over the segmented prostate. PH images showed greater morphological detail in the prostate by a surface area texture metric. Data suggests that texture was inversely correlated with age, and size was directly correlated with age. Small structures that were evident in HiSS images were similar in appearance to the hyperplasia/prostatic intraepithelial neoplasms (PIN), a precursor to prostate adenocarcinoma, that were evident on histology. The results (published in Magnetic Resonance in Medicine) suggest that very high resolution MRI can be used to study the development of prostate cancer in mice and the response of early prostate cancer and pre-cancer to therapy. Mr. Foxley was awarded a 2008 RSNA research trainee prize for his work.
**MR Imaging of Colitis and Colitis-Associated Early Cancers in Mice**

Drs. Devkumar Mustafi, Marc Bissonnette, Greg Karczmar and their colleagues have used high-resolution MRI to detect early colorectal tumors in mice and differentiation of early cancer from colitis. Ulcerative colitis is characterized by persistent or recurrent inflammation that can lead to colon cancer. Animal models have been widely used to study the pathogenesis and potential therapies for these types of colitis. However, non-invasive imaging methods that can differentiate colitis and early colorectal cancers in murine models as well as assess response to therapy are not available. These investigators explored the feasibility of imaging pre-malignant chronic colitis and distinguishing it from early colorectal tumors in mice. Figure 12 illustrates spin echo MR images of a control, tumor, and colitis-to-early colorectal tumor-bearing mice. The results from DCEMRI show that the contrast uptake in tumors is significantly different from that of colitis or normal colon (and muscle) following injection of Gd-DTPA as shown in the figure. The two-compartment model was used to analyze dynamic data over the tumor, colitis, and muscle tissues. Based on studies with control mice, mice with colitis, colorectal tumors, and mice with colitis transitioning to early colorectal cancer, they have demonstrated for the first time that functional MRI techniques in mice offer the potential to discriminate chronic colitis from neoplastic transformation of early colitis-associated colorectal cancers, thus making it possible to detect very early cancer non-invasively. The pre-clinical research led by Dr. Mustafi parallels clinical research led by Dr. Aytekin Oto to improve clinical MRI of colitis and colorectal cancer.

**Clinical and Pre-clinical Spectral Spatial Imaging of Breast Cancer**

Graduate Students Sean Foxley and Abbie Wood, working with Gregary Karczmar, PhD, have found that detection of tumor vasculature by MRI is a critical component of cancer screening. In clinical practice DCEMRI is used to detect dense tumor blood vessels. However, DCEMRI produces noisy data because of the need to image rapidly before contrast media washes out of tumors. In addition, DCEMRI may not be appropriate for all patients, particularly in the context of screening exams. Therefore, as part of SPORE funded research, the researchers are developing high spectral and spatial resolution imaging methods that can be used to detect tumor blood vessels without the need to inject contrast agents, based on the local magnetic susceptibility gradients produced by deoxyhemoglobin in deoxygenated tumor blood vessels (see Figure 13).

Mr. Foxley did his research using rodent models of cancer, and his work is ‘in press’ in Magnetic Resonance in Medicine. Figure 14 is an excerpt from the paper demonstrating agreement between detection of tumor microvasculature on HiSS images and DCEMRI detection of tumor vasculature.

Ms. Wood has developed methods for analyzing HiSS data from patients with breast cancer to detect dense tumor vasculature. Figure 14 demonstrates the analysis of water signal lineshape in each voxel to produce images of vasculature in a breast tumor.

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**Figure 12**

a) Image of a tumor implanted in rodent hind limb; this is a water peak height image calculated from spectral/spatial data; b) water peak height image with a blue overlay showing areas of dense vasculature identified from DCEMRI (blue scale - dark blue means sparse vessels, light blue means dense vessels) overlaid; c) water peak height image with superimposed image showing estimates of vascular density calculated from water spectral lineshape (red scale - dark to light red is lower to higher vascular density); d) images with pixels where DCEMRI and water lineshape analysis agree shown in green.
Very High Spectral and Spatial Resolution Imaging

Milica Medved, PhD, Gillian Newstead, MD, Greg Karczmar, PhD, and Funmi Olopade, MD, have developed very high spatial and spectral resolution (HiSS) imaging, and are testing it as a tool for evaluation of indeterminate breast lesions. They have achieved submillimeter spatial resolution in 1mm think slices, with enough spectral information to preserve the dynamic range and superior fat saturation associated with HiSS MRI. The resulting images (Figures 15, 16, 17) below show clearly delineated parenchyma and lesions, with high signal-to-noise.

**Figure 14**

a) Image of ductal carcinoma in situ (DCIS) of the human breast; this is a water peak height image calculated from spectral/spatial data; b) water peak height image with a yellow-red overlay showing areas of dense vasculature identified from lineshape analysis (yellow means sparse vessels, red means dense vessels); c) DCEMRI subtraction image from minute 2 post-injection. Areas with white pixel values indicate significantly-enhancing regions with dense vasculature.

**Figure 15**

(A) Sagittal HiSS image of a high risk volunteer, with spatial resolution of 0.5 x 0.5 mm, slice thickness 1 mm, and spectral resolution of 5 Hz. Four slices were acquired in 8 minutes; the arrow points to a blood vessel.

**Figure 16**

(Left) A sagittal HiSS image of a patient with infiltrating ductal carcinoma (grade III; arrow), with spatial resolution of 0.5 x 0.75 mm, and spectral resolution of 5 Hz. Four slices were acquired in 8 minutes; (Right) A maximum intensity projection image of four 1mm-thick sliced centered around the lesion (arrow) is shown.

**Figure 17**

Sagittal HiSS images showing parenchyma of three ‘high-risk’ volunteers are shown. The spatial resolution was 0.75 x 0.75 mm, with slice thickness of 1 mm, and spectral resolution of 18 Hz. Twelve slices were acquired in 8 minutes, for each patient.

**Improved Analysis of Dynamic Contrast Enhanced MRI Data**

Xiaobin Fan, PhD, and Gregory Karczmar, PhD, are studying Dynamic Contrast Enhanced MRI which involves measurement and analysis of contrast media uptake and washout following bolus injection. These studies are critical for, among other things, detecting and evaluating tumor vasculature and changes in tumor vasculature during therapy. However, there is no accepted method for analyzing contrast media uptake and washout. The widely used two compartment approach is not a good model for tumors because tumors are very heterogeneous on a microscopic level. Therefore, Dr. Fan and his
collaborators have developed a new approach to analysis of DCEMRI based on calculation of the impulse response function of the tumor. They developed a novel numerical procedure to deconvolute arterial input function (AIF) from contrast concentration vs. time curves and to obtain the impulse response function (IRF) for dynamic contrast enhanced MRI. A general simple mathematical model of the IRF was developed and the physiological meaning of the model parameters was determined by comparing them with the widely accepted two compartment model (TCM). The results demonstrate that the deconvolution procedure is a simple, robust, and useful technique. In addition, the IRF analysis leads to the derivation of novel parameters relating to tumor interstitial pressure and tumor vascular architecture, which may have clinical utility in diagnosis of cancers.

**Functional MRI and Human Brain Mapping**

Figure 19

a) Functional magnetic resonance image (in color) overlaid on an anatomical image (in grey) in one subject depicts the active areas after glucose ingestion; b): The signal time course of the hypothalamus after glucose ingestion. Time t = 0 min corresponds to the onset of drinking and the blue bar indicates the approximate duration of drinking.

Jia-Hong Gao, PhD, Co-Director of the Brain Research Imaging Center (BRIC), is developing a functional MRI (fMRI) and human brain mapping research program at the University of Chicago. The mission of the BRIC is the development and synergistic application of MRI techniques to neuroscience as well as a broad range of other medical research disciplines. In late 2008, a research-dedicated and the state-of-the-art 3T Philips MRI scanner will be installed in BRIC. This new scanner will be used to support all cutting-edge NIH funded imaging projects at our campus. Presently, Dr. Gao’s research activities are focused on several areas: (1) development of a novel fMRI technique, termed neuronal current MRI, that allows for substantial enhancement in the detection of brain activity in terms of both spatial and temporal resolution; (2) study of the biophysical mechanism of the homodynamic-based fMRI signal, and exploring the relationship between cerebral blood flow and oxygen metabolism during neuronal stimulation; (3) MRI measurements of the current density distribution in a body when an external current source is applied; (4) mapping of brain activation in the actions of glucose and alcohol; (5) development of diffusion tensor imaging as a biomarker for the study of brain trauma injury. The neuroimaging techniques developed in BRIC will greatly improve understating of the nature of normal brain function and help in the treatment of neurological disorders as well.

**Spin Resonance Imaging**

Graduate students Dan Xia, Emil Sidky, PhD, and Xiaochuan Pan, PhD, are conducting spin-resonance-based imaging. Nuclear magnetic resonance imaging (MRI) has become one of the dominant clinical and research imaging techniques. They have been investigating, developing, and evaluating a variety of efficient and accurate sampling schemes such as the spiral sampling schemes for fast spatial-spectral MRI. The researchers are also developing algorithms for optimal suppression of data noise and other artifacts that are likely to be contained in rapidly acquired data. Unlike MRI that is based upon nuclear spin resonances, which are generally in high abundance in biological samples, electron paramagnetic resonance imaging (EPRI) detects spin resonances of unpaired electrons of free radicals in samples and determines the spatial distributions of parameters of physiologic significance. Of particular interest is estimating oxygen concentration within tumors because such information is of paramount importance for detection, assessment, and monitoring of cancer status. In collaborating with Dr. Howard Halpern of the Department of Radiation and Cellular Oncology, they are investigating innovative sampling schemes for efficient and complete acquisition of EPRI data and also seek to develop algorithms for optimally processing the acquired data and for accurately reconstructing EPRI images.

**MRI Imaging of Pancreas and Heart**

Brian Roman, PhD, has continued the work in the pancreas and heart as well as developing new projects and collaborations with university investigators. One such recent collaboration is with Dr. Kathleen Millen in the department of Genetics. Dr. Millen’s investigates the genetics of brain formation and is interested in measuring brain volume of several mutant mice. Muhammad Haque, PhD, in the laboratory has been developing MRI protocols in order to measure the volume of the cerebellum in control and mutant mice. Figure 20 illustrates a typical image from the 9.4T scanner which highlights the cerebellum at 64 micron in plane resolution.
**Manganese Enhanced Magnetic Resonance Imaging (MEMRI) of Pancreatic Islet Function**

Diabetes is a metabolic disorder caused by inadequate supply or utilization of insulin, secreted by the pancreatic β-cells located in the islets. Presently pancreatic β-cell function is assessed via insulin release or indirectly via serum glucose levels. The lack of understanding about pancreatic physiology and β-cell mass is a major hurdle in therapy development. Knowing the functional efficiency of the pancreas would certainly be beneficial in the development of novel therapies aimed at maintaining or increasing β-cell function. Thus, development of non-invasive imaging modalities to evaluate β-cell function is needed.

β-cells are stimulated as a result of increased blood glucose levels which results in calcium (Ca+2) uptake through voltage-gated channels followed by insulin release. Manganese ions (Mn+2) are a Ca+2 analog and a T1 relaxation agent. Therefore β-cells activated by increased glucose in the presence of Mn+2 will demonstrate a change in MR signal intensity compared to non-activated cells. Muhammad Haque, PhD, in the laboratory acquired the first in-vivo functional imaging of rodent pancreas via Mn enhanced MRI (MEMRI) in response to glucose stimulation (see Figure 21).

**MR Imaging of Transplanted Pancreatic Islets**

Lara Leoni, PhD, and Muhammad Haque, PhD, have applied high resolution MEMRI to investigate the functionality of transplanted pancreatic islets (see Figure 22). Islets were transplanted into the kidney of nude mice previously rendered diabetic via streptozotocin injection. Mice that reverted to normal blood glucose were imaged at baseline and after injection of Mn and glucose stimulation. Initial studies suggest an increase in SNR following glucose stimulation. Further studies are ongoing in order to precisely quantify in-vivo SNR, T1 and T2 values of the transplanted islets.

**MRI Detection of Gene Expression**

Brian Roman, PhD, and his lab members have been developing techniques to use MR to detect gene expression in the heart. Their recent work has been investigating calcium handling in the heart and on how this is influenced by expression of the gene creatine kinase (CK). They are using transgenic mouse models which are deficient in CK. These hearts are imaged under baseline, increased workloads and hypertrophic conditions using manganese enhanced cardiac MRI (MEMRI). In wild-type mice, the MR signal increased following Mn infusion by 15–20% while it increased by 20–35% following dobutamine challenge. In addition to the signal enhancement, the wall thickness increased by 30% while it did not change for the CK deficient or hypertrophic mice. The signal enhancement was less for the hypertrophic wild-type and CK-M mice and there was no change in signal intensity for the treated CK deficient mice. This agreed with the group’s hemodynamic data where significant changes in contractility (dP/dt) due to Db, were only found in wild-type mice (see Figures 23 and 24).

To pursue the mechanism for this altered contrast enhancement, Dr. Roman and his team implemented gene array and RT-PCR analyses of these hearts that revealed CK deficient (CK-) mice exhibit altered calcium handling gene expression compared to control mice. The role creatine kinase plays in maintaining calcium homeostasis suggests that the altered MRI contrast is likely due to changes in genes regulating or binding calcium. Microarray analysis indicated a large upregulation in the expression of Guanylate Nucleotide binding protein 1 (GBP1) and S100A9. The increases in expression were...
confirmed using qRT-PCR analysis as indicated above in single (MCKO) and double (DBKO) creatine kinase deficient strains. These studies are aimed at elucidating changes in calcium handling to refine applications of Manganese-enhanced MRI. Additionally, differences in MRI data have been noted in mouse strains such as 129 and C57/129 hybrids harboring elevated expression of GBP1. The increased expression of GBP1 and S100A9 have also been confirmed in 129 and C57/129 hybrid animals (see Figures 25 and 26).

Wild-type mice pre (left) and post (right) Mn infusion. The increase in contrast is due to active calcium pumping and therefore Mn uptake particularly in the septum and left ventricular free wall of the heart.

Creatine kinase deficient mice pre (left) and post (right) Mn infusion. Unlike wild-type mouse hearts, CK deficient hearts do not demonstrate an increase in image contrast following Mn administration. This indicates an altered mechanism for calcium handling.

Quantitative RT-PCR results from wild-type (C57) and CK deficient mice. These data confirm the gene array results indicating that both cell signaling cascade pathways and calcium handling mechanisms are perturbed in the heart of CK deficient mice and is likely the source of both image contrast and functional differences.

Tomosynthesis

Optimization of Reconstruction Algorithms for Computerized Detection of Microcalcifications in Tomosynthesis

Ingrid Reiser, PhD, Beverly A. Lau, BS, and Robert M. Nishikawa, PhD, are developing an automated scheme for microcalcification detection in breast tomosynthesis volume images. Several reconstruction methods have been applied to tomosynthesis, which include iterative reconstruction, as well as filtered back projection. The appeal of the latter method is that it is computationally faster. This allows an increased resolution of the image volume, which may improve MC conspicuity. The purpose of this work was to compare detection performance of a CAD scheme, on breast images reconstructed with maximum-likelihood expectation maximization (ML-EM), or with filtered back projection (FBP). Figure 27 shows a subtle MC cluster in both reconstructions. For the ML-EM reconstructed images, at least 3 microcalcifications were detected for all cases. For the FBP reconstructed...
images, at least 3 microcalcifications were detected for 21 out of 22 cases, and 2 microcalcifications were detected in one case. They noted that ML-EM reconstruction was less sensitive to image artifacts such as insufficient dead pixel correction, or underexposure in individual projections. Algorithm performance showed a slight advantage for the ML-EM reconstruction; however this may be because the ML-EM algorithm results in images that are less noisy, since ML-EM reconstruction involves implicit image smoothing by use of unmatched projector-back projector pairs. This result was contrary to previous study that showed ML-EM was superior to FBP for breast masses.

**Microcalcification Detectability in Tomosynthesis: Effect of Scan Parameters**

Beverly A. Lau, BS, Ingrid Reiser, PhD, and Robert M. Nishikawa, PhD, are investigating the detectability of microcalcifications in breast tomosynthesis images. In this study, they examined the effect of acquisition geometry (the number of projection views and the total angle covered by those projections) and position of the microcalcification with respect to the center of the detector. Using computer simulation, they determined that when the projection is at a large angle the detectability depends on the position of the microcalcification with higher detectability when calcification is near the edge that is closest to the x-ray tube and lowest when near the opposite edge. The difference was 22% at 45 degrees. This is due to the difference in the x-ray path length when the x-ray tube is at large angles. When the tube is at 0 degrees there is no position dependence. Further they found that the detectability decreased when the angular range scanned by the x-ray tube increased and they found no dependence of detectability on the number of projection views. In the future, they will determine if these results apply when x-ray quantum noise and breast structure noise are considered in the simulation.

**Figure 27**

Subtle MC cluster – (Left) - maximum likelihood expectation maximization reconstruction; (Right) - filtered back projection reconstruction.
The molecular probe has been designed to shift its absorption spectrum when cleaved by specific proteases. This would allow the cleaved and uncleaved probes to be distinguished by the optoacoustic signal at different wavelengths. The imaging system will comprise a conventional ultrasonic transducer with a coupled optical fiber to deliver the stimulating near-infrared pulse. This will enable interlaced anatomical and molecular images to be acquired and superimposed.

**X-ray Fluorescence Imaging of Pancreatic Islets**

Research Associate Lara Leoni, PhD, Brian Roman, PhD, and Patrick La Riviere, PhD have continued using the scanning x-ray fluorescence microprobe at Sector 2 of the Advanced Photon Source to image the spatial distribution of exogeneous manganese that has been introduced into islets of Langerhans as a contrast agent for magnetic resonance imaging (MRI). The islets of Langerhans comprise the hormone-secreting cells in the pancreas, including the insulin-secreting beta cells whose dysfunction is a major cause of diabetes. The ability to assess the function of beta cells through in-vivo imaging would aid in assessing the progression and severity of diabetes as well as the success of therapies based on islet transplantation. Recently, Dr. Roman and his collaborators have shown that manganese can be employed as an MRI contrast agent for islet imaging since it is taken up through the calcium channels of functional, glucose-stimulated beta cells. However, the ability to draw quantitative conclusions about beta-cell functionality from manganese-enhanced MRI is limited by a lack of knowledge of how the manganese is actually distributed in the islets: how much of it is actually taken up by beta cells versus how much remains in the extracellular space. X-ray fluorescence imaging is an ideal tool for producing a map of exogenous manganese, as well as endogenous elements such as calcium and zinc, in isolated, intact islets.

**New Image Acquisition Strategies in X-Ray Fluorescence Computed Tomography (XFCT)**

XFCT is an emerging imaging modality that allows for the reconstruction of the distribution of nonradioactive elements within a sample from measurements of fluorescence x-rays produced by irradiation of the sample with synchrotron radiation. The ability to map elemental distributions within a sample has many potential biomedical applications, including mapping of iodine distributions in the thyroid, detection of heavy metals in the bones, and mapping of cisplatin distribution in cancer cells. This year, Patrick La Riviere, PhD, in collaboration with Ling-Jian Meng, PhD, of the University of Illinois Urbana-Champaign and scientists at the Advanced Photon Source, have explored a new image acquisition strategy based on the use of imaging detectors and multiple pinhole collimators. It promises order-of-magnitude faster imaging times and simpler data processing. See Figure 29.

![Volume rendering of a 3D x-ray fluorescence image of three 0.75 mm tubes containing three different elements: zinc (blue), bromine (green), and iron (red). The 3D image was acquired by illuminating one slice at a time through the object with monochromatic x-rays and imaging the stimulated characteristic x-rays with an imaging detector and multi-pinhole collimator.](image)

**Quantitative Optical Imaging**

Research Professional Lynnette Gerhold, PhD, Jeffrey Souris, PhD, Patrick La Riviere, PhD, and Chin-Tu Chen, PhD, have been collaborating with Rosie Xing, PhD, in the Departments of Pathology and Radiation & Cellular Oncology to develop evaluation, calibration, and correction strategies for making the bioluminescence and fluorescence imaging methods as more of quantitative imaging approaches. They are investigating systematically the physical factors that affect the accuracy and precision of the quantitative measurements in using these optical imaging techniques, develop novel strategies and methods for correction of these physical effects in order to make quantitative measurements feasible or improved,
and design and implement validation or evaluation methodologies for characterization of these physical effects, correction strategies, as well as resulting quantitative accuracies. Dr. Souris has also developed a novel approach to implant flexible and transparent materials as window to view optical signals from tissues and organs inside the animal models that previously can not be viewed because of the lack of signals transmitted through tissues and skins. This technique is now being applied to several applications in animal imaging studies for further validation and development.

**Multi-Modality Imaging Probes**

Jeffrey Souris, PhD, and Chin-Tu Chen, PhD, have been collaborating with Liao-hai Chen, PhD, in the Biological Sciences Division of the Argonne National Laboratory to utilize phage and micelle as nanoplatforms to develop novel imaging probes, contrast agents, and tracers that share the same shell vehicle which can “carry” a variety of different agents for various imaging modalities, including CT, PET, SPECT, optical imaging, ultrasound, etc. These nanoparticles can also incorporate targeting devices at their surface to home-in onto specific sites of the cells or tissues that are to be traced, images, and probed in order to increase substantially the uptake ratio. In collaboration with Kurt M. Lin, PhD, and Leuwei Lo, PhD, of the Medical Engineering Research Division of the National Health Research Institute in Taiwan, they are also using other tracer methodologies and nanotechnology to design and build innovative multi-modality imaging probes, which have been utilized in a variety of applications such as imaging of breast cancer. The theme of this line of research is to design and develop novel imaging probes that can be used for multiple imaging modalities in order to assess a variety of structural or functional information of the same tissues or organs.

**Image Analysis In Chest Imaging**

**Computerized Detection of Lung Nodules in Thin-Section CT Images by use of Selective Enhancement Filters and an Automated Rule-Based Classifier**

Qiang Li, PhD, Feng Li, MD, PhD, and Kunio Doi, PhD, have been developing a CAD scheme for lung nodule detection in order to assist radiologists in the detection of lung cancer in thin-section CT images. Our database consisted of 117 thin-section CT scans with 153 nodules, obtained from a lung cancer screening program at a Japanese university (85 scans, 91 nodules) and from clinical work at an American university (32 scans, 62 nodules). The database included nodules of different sizes (4-28 mm, mean 10.2 mm), shapes, and patterns (solid and ground-glass opacity (GGO)). Our CAD scheme consisted of modules for lung segmentation, selective nodule enhancement, initial nodule detection, feature extraction, and classification. The selective nodule enhancement filter was a key technique for significant enhancement of nodules and suppression of normal anatomic structures such as blood vessels, which are the main sources of false positives. Use of an automated rule-based classifier for reduction of false positives was another key technique; it resulted in a minimized overtraining effect and an improved classification performance. They used a case-based four-fold cross-validation testing method for evaluation of the performance levels of the computerized detection scheme. Their CAD scheme achieved an overall sensitivity of 86% (small: 76%, medium-sized: 94%, large: 95%; solid: 86%, mixed GGO: 89%, pure GGO: 81%) with 6.6 false positives per scan; an overall sensitivity of 81% (small: 69%, medium-sized: 91%, large: 91%, solid: 79%, missed GGO: 88%, pure GGO: 81%) with 3.3 false positives per scan; and an overall sensitivity of 75% (small: 60%, medium-sized: 88%, large: 87%; solid: 70%, mixed GGO: 87%, pure GGO: 81%) with 1.6 false positives per scan. In conclusion, the experimental results indicate that their CAD scheme with its two key techniques can achieve a relatively high performance for nodules presenting large variations in size, shape, and pattern.

**Lung Cancers Missed on Chest Radiographs: Results Obtained with a Commercial Computer-Aided Detection Program**

Feng Li, MD, PhD, Roger E. Engelmann, MS, Charles E. Metz, PhD, Kunio Doi, PhD, and Heber MacMahon, MD, conducted the study to retrospectively determine the sensitivity of and number of false-positive marks made by a commercially available computer-aided detection (CAD) system for identifying lung cancers previously missed on chest radiographs by radiologists, with histopathologic results as the reference standard. A CAD nodule detection program was applied to 34 posteroanterior digital chest radiographs obtained in 34 patients (21 men, 13 women; mean age, 69 years). All 34 radiographs showed a nodular lung cancer that was apparent in retrospect but had not been mentioned in the report. Two radiologists identified these radiologist-missed cancers on the chest radiographs and graded them for visibility, location, subtlety (extremely subtle to extremely obvious on a 10-point scale), and actionability (actionable or not actionable according to whether the radiologists probably would have recommended follow-up if the nodule had been detected). The CAD results were analyzed to determine the numbers of cancers and false-positive nodules marked and to correlate the CAD results with the nodule grades for subtlety and actionability. The x2 test or Fisher exact test for independence was used to compare CAD sensitivity between the very subtle (grade 1-3) and relatively obvious (grade >3) cancers and between the actionable and not actionable cancers. The CAD program had
An overall sensitivity of 35% (12 of 34 cancers), identifying seven (30%) of 23 very subtle and five (45%) of 11 relatively obvious radiologist missed cancers (p = .21) and detecting two (25%) of eight missed not actionable and ten (38%) of 26 missed actionable cancers (p=.33). The CAD program made an average of 5.9 false-positive marks per radiograph. In conclusion, the described CAD system can mark a substantial proportion of visually subtle lung cancers that are likely to be missed by radiologists.

An Investigation of Radiologists’ Perception of Lesion Similarity: Observations with Paired Breast Masses on Mammograms and Paired Lung Nodules on CT Images

Seiji Kumazawa, PhD, Chisako Muramatsu, PhD, Qiang Li, PhD, Feng Li, PhD, Junji Shiraishi, PhD, Philip Caligiuri, MD, Robert A. Schmidt, MD, Heber MacMahon, MD, and Kunio Doi, PhD, conducted an observer study to investigate whether radiologists can judge similarities in pairs of breast masses and lung nodules consistently and reproducibly. They used eight pairs of breast masses on mammograms and eight pairs of lung nodules on computed tomographic images, for which subjective similarity ratings ranging from 0 to 1 were determined in their previous studies. From these, four sets of image pairs were created (i.e., a set of eight mass pairs, a set of eight nodule pairs, and two mixed sets of four mass and four nodule pairs). Eight radiologists, including four breast radiologists and four chest radiologists, compared all combinations of the eight pairs in each set using a two-alternative forced-choice (2AFC) method to determine the similarity ranking scores by identifying which pair was more similar than the other pair based on the overall impression for diagnosis. In the mass set and nodule set, the relationship between the average subjective similarity ratings and the average similarity ranking scores by 2AFC indicated very high correlations (r = 0.91 and 0.88). Moreover, in the two mixed sets, the correlations between the average subjective similarity ratings and the average similarity ranking scores were also very high (r = 0.90 and 0.98). Thus, radiologists were able to compare the similarities for pairs of lesions consistently, even in the unusual comparison of pairs of completely different types of lesions. In conclusion, subjective similarity of a pair of lesions in medical images can be quantified consistently by a group of radiologists. The concept of similarity of lesions in medical images can be subjected to rigorous scientific research and investigation in the future.


Kenji Suzuki, PhD, Samuel G. Armato, III, PhD, Heber MacMahon, MD, and their colleagues are developing a novel temporal-subtraction (TS) technique combined with “virtual dual-energy” technology for improved conspicuity of growing cancers and other pathologic changes in digital chest radiography (CXR). Digital CXR makes use of advanced image-processing techniques in the radiology viewing environment. A TS technique provides enhanced visualization of tumor growth and subtle pathologic changes between previous and current CXRs from the same patient. The researchers’ purpose was to develop a new TS technique incorporating “virtual dual-energy” technology to improve its enhancement quality. Our TS technique consisted of ribcage edge detection, rigid body transformation based on a global alignment criterion, image warping based on local spatial displacement vectors under the maximum cross-correlation criterion, and subtraction between the registered previous and current images. A major problem with TS was obscuring of abnormalities by rib artifacts due to misregistration. To reduce the rib artifacts, the team developed a massive-training artificial neural network (MTANN) for separation of ribs from soft tissue. The MTANN was trained with input CXRs and the corresponding “teaching” soft-tissue CXRs obtained with dual-energy radiography. Once trained, the MTANNs...
did not require a dual-energy system and provided soft-tissue images in which ribs were substantially suppressed (thus the term “virtual dual-energy” technology). The database consisted of 100 sequential pairs of digital CXR studies from 53 patients. To assess the registration accuracy and clinical utility, a chest radiologist subjectively rated original TS and rib-suppressed TS images on a 5-point scale. By use of “virtual dual-energy” technology, the contrast of ribs in the original CXRs was reduced to 8% while maintaining that of soft tissue; thus, rib artifacts in the TS images were reduced substantially. The registration accuracy and clinical utility ratings for TS rib-suppressed images (3.7; 3.9) were significantly better than those for the original TS images (3.5; 3.6) (p<0.01; p<0.02, respectively). This “virtual dual-energy” technology reduced rib artifacts in TS CXRs and improved the enhancement quality of TS images for the assessment of pathologic change (see Figure 30). Thus, TS combined with “virtual dual-energy” technology would be useful for radiologists in the assessment of tumor growth and other pathologic changes between previous and current digital CXRs.

Usefulness of Temporal Subtraction Images for Identification of Interval Changes in Successive Whole-Body Bone Scans: JAFROC Analysis of Radiologists’ Performance
Junji Shiraishi, PhD, Daniel Appelbaum, MD, Yonglin Pu, MD, Qiang Li, PhD, Lorenzo Pesce, PhD, and Kunio Doi, PhD, evaluated the usefulness of temporal subtraction images obtained from two successive whole-body bone scans, in terms of improvement in radiologists’ diagnostic accuracy in detecting interval changes and of a reduction in reading time, by use of a jackknife free-response receiver operating characteristic (JAFROC) analysis method. Twenty pairs of successive whole-body bone scans (72 consented interval changes) and their temporal subtraction images were used for an observer performance study. In the first session of the observer study, without temporal subtraction images, the previous and current images were shown to five radiologists independently for their marking of the locations on current images and confidence ratings on potential interval changes from previous images. In the second session, temporal subtraction images were shown together with the modified previous and current images. JAFROC analysis was used for assessing the statistical significance of differences between radiologists’ performance without and with temporal subtraction images. The average sensitivity for detecting interval changes was improved from 58.6% to 73.2% at a false-positive rate of two per case by use of temporal subtraction images, and the difference was statistically significant by use of JAFROC analysis (p = .035). In addition, the mean reading time per case was reduced considerably from 134 seconds to 91 seconds (p<.01). In conclusion, temporal subtraction imaging for successive whole-body bone scans has the potential greatly to assist radiologists by increasing both their accuracy and productivity.

Usefulness of Computer-Aided Diagnosis Schemes for Vertebral Fractures and Lung Nodules on Chest Radiographs
Satoshi Kasai, PhD, Feng Li, MD, Junji Shiraishi, PhD, and Kunio Doi, PhD, retrospectively evaluated the usefulness of CAD schemes to radiologist performance in the simultaneous detection of vertebral fractures and lung nodules on chest radiographs. The group evaluated posteroanterior and lateral chest images of 21 patients with vertebral fractures, 31 patients with lung nodules, and 10 persons acting as controls. The total number of subjects was 60 because both lesions were present in four patients. Eighteen radiologists were asked to detect vertebral fractures and nodules simultaneously on posteroanterior and lateral images. The observers’ performance was evaluated with use of ROC and jackknife free-response ROC curves. With the CAD scheme, the average area under the ROC curve for detection of vertebral fractures improved from 0.906 to 0.951 (p = 0.002). That for lung nodules also improved, but the improvement was not statistically significant (0.804-0.816, p = 0.297). The figure-of-merit values obtained with the jackknife free-response ROC program improved from 0.585 to 0.680 (p<0.001) for vertebral fractures and from 0.622 to 0.650 (p=0.017) for nodules, both results having
statistical significance. Average sensitivity in the detection of lesions improved from 59.8% to 69.3% for vertebral fractures and from 64.9% to 67.6% for nodules. Therefore, in the detection of vertebral fractures and lung nodules on chest images, diagnostic accuracy among radiologists improves with the use of CAD.

Reference Image Database to Evaluate Response to Therapy in Lung Cancer
Samuel G. Armato III, PhD, is the local Principal Investigator of the NCI-sponsored Reference Image Database to Evaluate Response (RIDER) project, which is investigating the role of imaging in the evaluation of tumor response to therapy in lung cancer. Critical to the clinical evaluation of effective novel therapies for lung cancer is the early and accurate determination of tumor response, which requires an understanding of the sources of uncertainty in tumor measurements and subsequent attempts to minimize their impact on the assessment of the therapeutic agent. The RIDER project seeks to develop a consensus approach to the optimization and benchmarking of software tools for the assessment of tumor response to therapy and to provide a publicly available database of serial images acquired during lung cancer drug and radiation therapy trials. Images of phantoms and patient images acquired under situations in which tumor size or biology are known to be unchanged also will be provided. The RIDER project will create standardized methods for benchmarking software tools to reduce sources of uncertainty in vital clinical assessments such as whether a specific tumor is responding to therapy. One recurring and very significant issue in the evaluation of new therapies, such as for non-surgically treated lung cancer, is the assessment of response to therapy. Establishing therapy safety and effectiveness is essential for therapy regulatory approval and for third-party payors to approve payments for that therapy. The current approval metric, however, is based on patient survival compared against a “best therapy” standard in a randomized controlled study. Such studies are expensive in terms of both time and money. Moreover, since such studies may require large numbers of subjects, the commencement of one study means that other promising therapeutic agents are never tested. Such an approach therefore denies the general population access to many potentially useful agents. The RIDER project is an important step in replacing this old paradigm with a consensus-based process of developing well-defined image-based metrics to measure tumor-specific response as the primary outcome. This will allow many more therapeutic agents to be tested more rapidly, either singly or in combination, with large cost savings and without detriment to subject safety. A final randomized controlled study with patient survival as the end point may still be needed for final regulatory approval, but such a study then may be performed with knowledge that the best available therapy has been chosen for evaluation.

Computer-Aided Diagnosis for the Classification of Focal Liver Lesions by Use of Contrast-Enhanced Ultrasoundography
Junji Shiraiishi, PhD, Katsutoshi Sugimoto, MD, Fuminori Moriyasu, MD, and Kunio Doi, PhD, developed a CAD scheme for classifying focal liver lesions (FLLs) as liver metastasis, hemangioma, and three histologic differentiation types of hepatocellular carcinoma (HCC), by use of microflow imaging (MFI) of contrast-enhanced ultrasound. One hundred and three FLLs obtained from 97 cases used in this study consisted of 26 metastases (15 hyper- and 11 hypovascularity types), 16 hemangiomas (five hyper- and 11 hypovascularity types) and 61 HCCs: 24 well differentiated (w-HCC), 28 moderately differentiated (m-HCC), and nine poorly differentiated (p-HCC). Pathologies of all cases were determined based on biopsy or surgical specimens. Locations and contours of FLLs on contrast-enhanced images were determined manually by an experienced physician. MFI was obtained with contrast-enhanced low-mechanical-index (MI) pulse subtraction imaging at a fixed plane which included a distinctive cross-section of the FLL. In MFI, the inflow high signals in the plane, which were due to the vascular patterns and the contrast agent, were accumulated following flash scanning with a high-MI ultrasound exposure. In the initial step of our computerized scheme, a series of the MFI images was extracted from the original cine clip (AVI format). We applied a smoothing filter and time-sequential running average techniques in order to reduce signal noise on the single MI image and cyclic noise on the sequential MFI images, respectively. A kidney, vessels, and a liver parenchyma region were segmented automatically by use of the last image of a series of MFI images. The authors estimated time-intensity curves for an FLL by use of a series of MFI images, in order to determine temporal features such as estimated replenishment times at early and delayed phases, flow rates, and peak times. In addition, they extracted morphologic and gray-level image features which were determined based on the physician’s knowledge of the diagnosis of the FLL, such as the size of lesion, vascular patterns, and the presence of hypoechoic regions. They employed a cascade of six independent artificial neural networks (ANNs) by use of extracted temporal and image features for classifying five types of liver diseases. A total of 16 temporal and image features, which were selected from 43 initially extracted features, were used for six different ANNs for making decisions at each decision in the cascade. The ANNs were trained and tested with a leave-one-lesion-out test method. The classification accuracies for the 103 FLLs
were 88.5% for metastasis, 93.8% for hemangioma, and 86.9% for all HCCs. In addition, the classification accuracies for histologic differentiation types of HCCs were 79.2% for w-HCC, 50.0% for m-HCC, and 77.8% for p-HCC. The CAD scheme for classifying FLGs by use of the MFI on contrast-enhanced ultrasonography has the potential to improve the diagnostic accuracy in the histologic diagnosis of HCCs and the other liver diseases.

**Automated CT Liver Volumetry by Use of Three-Dimensional Fast-Marching and Level-Set Segmentation**

Kenji Suzuki, PhD, Masatoshi Hori, MD, PhD, Aytekin Oto, MD, Richard Baron, MD, and their colleagues are developing an automated scheme for segmenting and calculating liver volume in hepatic CT by means of 3D fast-marching and level-set segmentation algorithms. Automatic liver segmentation on hepatic CT images is challenging because the liver often abuts other organs of similar density. The researchers' purpose was to develop an automated liver segmentation scheme based on a 3D level-set algorithm for measuring liver volumes. Hepatic CT scans of eighteen prospective liver donors were obtained under a liver transplant protocol. Scans were acquired with a multi-detector CT system with a 16-, 40-, or 64-channel detector scanner (Brilliance, Philips Medical Systems, Netherlands). They developed an automated liver segmentation scheme for volumetry of the liver in CT, consisting of five steps. First, a 3D anisotropic diffusion smoothing filter was applied to CT images for removing noise while preserving the structures in the liver, followed by a gradient magnitude filter for enhancing liver edges. A nonlinear gray-scale enhancement filter was applied to the gradient magnitude image for further enhancing the boundary of the liver. By use of the enhanced gradient magnitude image as a speed function, a 3D fast-marching algorithm generated an initial surface that roughly estimated the shape of the liver. A 3D level-set segmentation algorithm refined the initial surface so as to fit the liver boundary more accurately (see Figure 31 for a segmentation result). The liver volume was calculated based on the refined liver surface. Automated volumes were compared to manually determined liver volumes. The mean liver volume obtained with our scheme was 1598 cc (range: 1002-2415 cc), whereas the mean manual volume was 1,535 cc (range: 1,007-2,435 cc). The mean absolute difference between automated and manual volumes was 128 (9.5%) ± 119 (9.4%) cc. The two volumetrics reached excellent agreement (the intra-class correlation coefficient was 0.89) with no statistically significant difference (p=0.13). The processing time by the automated method was 2-5 min. per case (Intel, Xeon, 2.7 GHz), whereas that by manual segmentation was approximately 50-60 min. per case. CT liver volumetrics based on an automated scheme agreed excellently with manual volumetrics and required substantially less completion time. Thus, the automated scheme provides an efficient and accurate way of measuring liver volumes in CT.

**A CAD Utilizing 3D Massive-Training ANNs for Detection of Flat Lesions in CT Colonography in a Large Multicenter Clinical Trial**

Kenji Suzuki, PhD, Abraham H. Dachman, MD, and their colleagues are developing a computer-aided diagnostic (CAD) scheme for detection of flat lesions (also called flat polyps or depressed polyps) in CT colonography (CTC) in a large multicenter clinical trial in collaboration with Don C. Rockey, MD, at the Southwest Medical Center of the University of Texas. Flat lesions in the colon are a major source of false-negative interpretations in CTC. A major challenge in CAD schemes is the detection of flat lesions that exhibit uncommon flat morphology. A flat lesion on a fold (10 mm; adenoma) in the cecum was detected correctly by the MTANN CAD scheme (indicated by an arrow). A small flat lesion (6 mm; adenoma) in the cecum was detected correctly by the MTANN CAD scheme.
of flat lesions, because existing CAD schemes are designed for detecting the common bulbous polyp shape. The goal was to develop a CAD scheme for detection of flat lesions in CTC. The researchers developed a CAD scheme consisting of colon segmentation based on histogram and morphologic analysis, detection of polyp candidates based on intensity-based and morphologic feature analysis, and linear discriminant analysis for classification of the candidates as polyps or non-polyps. To detect flat lesions, the group developed a “tolerant” morphologic analysis method in the polyp detection step for accommodating the analysis to include a flat shape. For reduction of false-positive (FP) detections, a 3D massive-training artificial neural networks (MTANNs) was designed to differentiate flat lesions from various types of non-polyps. An independent database consisting of CTC scans of 25 patients obtained from a multicenter clinical trial in which 15 institutions participated nationwide was utilized. Each patient was scanned in the supine and prone positions with collimations of 1.0–2.5 mm and reconstruction intervals of 1.0–2.5 mm. All patients underwent “reference-standard” optical colonoscopy. Flat lesions were determined under either “height” (< 3 mm high) or “ratio” (height < 1/2 long axis) criteria. Twenty-eight flat lesions were identified. Among them, 11 (39%) were false negatives in CTC. Lesion sizes ranged from 6–18 mm, with an average of 9 mm. The MTANN CAD scheme detected 68% (19/28) of flat lesions, including six lesions “missed” by reporting radiologists in the original clinical trial, with 10 (249/25) FP s per patient. Figure 32 shows examples of flat lesions, which are very small or on a fold (these are major causes of human misses). Some flat lesions are known to be histologically aggressive; therefore, detection of such lesions is critical clinically, but they are difficult to detect because of their uncommon morphology. It should be noted that these two cases were “missed” by reporting radiologists in the original trial; thus, detection of these lesions may be considered “very difficult.” This scheme would be useful for detecting flat lesions which are a major source of false negatives, thus potentially improving radiologists’ sensitivity in their detection of polyps in CTC.

Image Analysis

In Breast Imaging

Comparison of CAD on Digitized Screen-Film Mammograms and Full-Field Digital Mammograms
As part of her doctoral dissertation, Laura Yarusso, PhD, working in conjunction with Robert Nishikawa, PhD, Alexandra Edwards, MA, and John Papaioannou, MS, has compared the performance of different components of a computer-aided detection (CADe) scheme for clustered calcifications on mammograms. The goals of this research were to measure and compare image quality between full-field digital mammography (FFDM) and digitized screen-film mammography (dSFM), and to investigate the effect of image quality differences on the multiple components of our CADe scheme for the detection of clustered microcalcifications. The main hypothesis tested was that the superior image quality of FFDM relative to dSFM would result in improvements to multiple aspects of CADe performance.

Previously the group showed using test objects that FFDM was able to depict small objects on the size of calcifications with higher accuracy and precision than for dSFM. Recently, using bone chips and cadaver breasts, they found that with this higher accuracy and precision, the feature analysis component of the CADe scheme was improved for seven of eight features analyzed. This resulted in higher performance for the CADe algorithm when analyzing FFDM images compared to analyzing dSFM images. This is an important result as FFDM systems replace SFM systems.

Evaluation of Computer-Aided Diagnosis on a Large Clinical Full-Field Digital Mammographic Dataset
Hui Li, PhD, Maryellen L. Giger, PhD, Yading Yuan, BS, Weijie Chen, PhD, Karla Horsch, PhD, Li Lan, MS, Andrew R Jamieson, BS, Charlene A Sennett, MD, and Sanaz A Jansen, MS converted and optimized their previously developed computerized analysis methods for use with images from full-field digital mammography (FFDM) for breast mass classification in order to aid in the diagnosis of breast cancer. Seven hundred and thirty-nine full-field digital mammographic images, which contained 287 biopsy-proven breast mass lesions, of which 148 lesions were malignant and 139 lesions were benign, were retrospectively collected. Lesion margins were delineated by an expert breast radiologist and were used as the truth for lesion-segmentation evaluation. The computerized image analysis method consisted of several steps: 1) identified lesions were automatically extracted from the parenchymal background using computerized segmentation methods; 2) a set of image characteristics (mathematical descriptors) were automatically extracted from image data of the lesions and surrounding tissues; and 3) selected features were merged into an estimate of the probability of malignancy using a Bayesian artificial neural network classifier. Performance of the analyses was evaluated at various stages of the conversion using receiver operating characteristic (ROC) analysis. An AUC value of 0.81 was obtained in the task of distinguishing between malignant and benign mass lesions in a round-robin by case evaluation on the entire FFDM dataset. They failed to show a statistically significant difference (p value=0.83) as compared with results from their previous study in which the computerized classification was performed on digitized screen-film.
mammograms (DSFM). Thus, in conclusion, their computerized analysis methods developed on digitized screen-film mammography can be converted for use with FFDM. Results show that the computerized analysis methods for the diagnosis of breast mass lesions on FFDM are promising, and can potentially be used to aid clinicians in the diagnostic interpretation of FFDM.

**Determination of Subjective Similarity for Pairs of Masses and Pairs of Clustered Microcalcifications on Mammograms: Comparison of Similarity Ranking Scores and Absolute Similarity Ratings**

The presentation of images that are similar to that of an unknown lesion seen on a mammogram may be helpful for radiologists to correctly diagnose that lesion. For similar images to be useful, they must be quite similar from the radiologists’ point of view. Chisako Muramatsu, PhD, Qiang Li, PhD, Robert A. Schmidt, MD, Junji Shiraishi, PhD, Kenji Suzuki, PhD, Gillian M. Newstead, MD, and Kunio Doi, PhD, have been trying to quantify the radiologists’ impression of similarity for pairs of lesions and to establish a “gold standard” for development and evaluation of a computerized scheme for selecting such similar images. However, it is considered difficult to reliably and accurately determine similarity ratings, because they are subjective. In this study, we compared the subjective similarities obtained by two different methods, an absolute rating method and a 2-alternative forced-choice (2AFC) method, to demonstrate that reliable similarity ratings can be determined by the responses of a group of radiologists. The absolute similarity ratings were previously obtained for pairs of masses and pairs of microcalcifications from five and nine radiologists, respectively. In this study, similarity ranking scores for eight pairs of masses and eight pairs of microcalcifications were determined by use of the 2AFC method. In the first session, the eight pairs of masses and eight pairs of microcalcifications were grouped and compared separately for determining the similarity ranking scores. In the second session, another similarity ranking score was determined by use of mixed pairs, i.e., by comparison of the similarity of a mass pair with that of a calcification pair. Four pairs of masses and four pairs of microcalcifications were grouped together to create two sets of eight pairs. The average absolute similarity ratings and the average similarity ranking scores showed very good correlations in the first study (Pearson’s correlation coefficients: 0.94 and 0.98 for masses and microcalcifications, respectively). Moreover, in the second study, the correlations between the absolute ratings and the ranking scores were also very high (0.92 and 0.96), which implies that the observers were able to compare the similarity of a mass pair with that of a calcification pair consistently. These results provide evidence that the concept of similarity for pairs of images is robust, even across different lesion types, and that radiologists are able to reliably determine subjective similarity for pairs of breast lesions.

**Automated Method for Improving System Performance of Computer-Aided Diagnosis in Breast Ultrasound**

Karen Drukker, PhD, Charlene A Sennett, MD, and Maryellen L Giger, PhD, demonstrated the feasibility of their computerized auto-assessment method in which a computer-aided diagnosis (CADx) system itself provides a level of confidence for its estimate for the probability of malignancy for each radiologist-identified lesion. The computer performance was assessed within a leave-one-case-out protocol using a database of sonographic images from 542 patients (19% cancer prevalence). They investigated the potential of computer-derived confidence levels both 1) as an output aid to radiologists and 2) as an automated method to improve the computer classification performance in the task of differentiating between cancerous and benign lesions for the entire database. For the former, the CADx classification performance was assessed within ranges of confidence levels. For the latter, the computer-derived confidence levels were used in the determination of the computer-estimated probability of malignancy for each actual lesion based on probabilities obtained from different views. The use of this auto-assessment method resulted in the modest but statistically significant increase in the area under the ROC curve (AUC value) of 0.01 with respect to the performance obtained using the ‘traditional’ CADx approach, increasing the AUC value from 0.89 to 0.90 (p-value 0.03). They believe that computer-provided confidence levels may be helpful to radiologists who are using CADx output in diagnostic image interpretation as well as for automated improvement of the CADx classification for cancer.

**Breast Ultrasound Computer-Aided Diagnosis: Performance on a Large Clinical Diagnostic Population**

Karen Drukker, PhD, Nicholas Gruszauskas, PhD, Charlene A. Sennett, MD, and Maryellen L. Giger, PhD, evaluated the performance of their computer-aided diagnosis (CADx) workstation in the task of classifying cancer in a realistic dataset representative of a clinical diagnostic breast ultrasound practice. The database consisted of consecutive diagnostic breast ultrasound examinations acquired with a Philips HDI5000 scanner, collected with informed consent under an approved IRB and HIPAA compliant protocol. Images from 695 patients were collected for this study and images from all patients presenting with at least one sonographically visible lesion were used (508 patients with a total of 1046 distinct abnormalities); 101 patients had breast cancer. They presented results both for patients for whom lesion pathology was proven by either biopsy or aspiration (183 patients), and for all patients irrespective of biopsy-status (508 patients). The ability of the CADx workstation to distinguish malignancies from benign lesions was evaluated with a leave-one-out-by-case analysis. The clinical specificity of the radiologists for this dataset was determined by the biopsy rate and outcome. In the task of distinguishing cancer from all other lesions sent to biopsy, the CADx workstation obtained an area under the ROC curve (AUC value) of 0.01 with respect to the performance obtained using the ‘traditional’ CADx approach, increasing the AUC value from 0.89 to 0.90 (p-value 0.03). They believe that computer-provided confidence levels may be helpful to radiologists who are using CADx output in diagnostic image interpretation as well as for automated improvement of the CADx classification for cancer.
The automated classification of sonographic breast lesions is generally accomplished by extracting and quantifying various features from the lesions. The selection of images to be analyzed, however, is usually left to the radiologist. Nicholas P. Gruszauskas, PhD, Karen Drukker, PhD, Maryellen L. Giger, PhD, Charlene A. Sennett, MD, and Lorenzo L. Pesce, PhD, presented an analysis of the effect that image selection can have on the performance of a breast ultrasound computer-aided diagnosis system. A database of 344 different sonographic lesions was analyzed for this study (219 cysts/benign processes, 125 malignant lesions). Three different image selection protocols were used in the automated classification of each lesion: all images, first image only, and randomly selected images. After image selection, two different protocols were used to classify the lesions: a) the average feature values were input to the classifier, or b) the classifier outputs were averaged together. Both protocols generated an estimated probability of malignancy. Round-robin analysis was performed using a Bayesian neural network-based classifier. Receiver operating characteristic analysis was used to evaluate the performance of each protocol. Significance testing of the performance differences was performed via 95% confidence intervals and non-inferiority tests. The differences in the area under the ROC curves were never more than 0.02 for the primary protocols. Non-inferiority was demonstrated between these protocols with respect to standard input techniques (all images selected and feature averaging). In conclusion, they showed that their automated lesion classification scheme is robust and can perform well when subjected to variations in user input.

**Robustness of a Breast Ultrasound Computer-Aided Diagnosis System across Different Patient Populations**

Nicholas P. Gruszauskas, PhD, Karen Drukker, PhD, and Maryellen L. Giger, PhD, in a collaboration with Ruey-Feng Chang, PhD, from the Department of Computer Science and Information Engineering, National Taiwan University, Taipe, Taiwan investigated the robustness of the University of Chicago breast ultrasound computer-aided diagnosis system (CADx) when it is used across different patient populations. A sonographic database consisting of 433 lesions (127 malignant, 306 benign) from patients in the United States was used in the training of the breast ultrasound CADx system. A second sonographic database consisting of 456 lesions (145 malignant, 311 benign) was obtained from a separate patient population from Asia and used to test the trained classifier. Four sonographic features were extracted from each lesion (shape, margin sharpness, posterior acoustic behavior, and texture). These features were used to train a Bayesian neural network classifier. Both round-robin and independent testing were used to evaluate the classifier with the two databases. Performance was assessed by calculating the area under the ROC curve (AUC) for each test. The AUC of the independent test was 0.80 while the AUCs for the round-robin tests were 0.87 and 0.88 for the Asian and American databases, respectively. The difference between the independent test AUC and the round-robin AUC for the Asian database was statistically significant (p-value=0.02). This work indicates that the University of Chicago breast ultrasound CADx system is moderately robust across different patient populations. The statistically significant difference between the AUCs of the Asian database along with the similarity of the round-robin AUCs indicate that while the sonographic features used by the system are useful in both databases, their relative importance differs. This motivates the future exploration of optimal feature sets to improve the overall performance of the CADx system.

**Performance of Breast Ultrasound Computer-Aided Diagnosis: Dependence on Image Selection**

The automated classification of sonographic breast lesions is generally accomplished by extracting and quantifying various features from the lesions. The selection of images to be analyzed, however, is usually left to the radiologist. Nicholas P. Gruszauskas, PhD, Karen Drukker, PhD, Maryellen L. Giger, PhD, Charlene A. Sennett, MD, and Lorenzo L. Pesce, PhD, presented an analysis of the effect that image selection can have on the performance of a breast ultrasound computer-aided diagnosis system. A database of 344 different sonographic lesions was analyzed for this study (219 cysts/benign processes, 125 malignant lesions). Three different image selection protocols were used in the automated classification of each lesion: all images, first image only, and randomly selected images. After image selection, two different protocols were used to classify the lesions: a) the average feature values were input to the classifier, or b) the classifier outputs were averaged together. Both protocols generated an estimated probability of malignancy. Round-robin analysis was performed using a Bayesian neural network-based classifier. Receiver operating characteristic analysis was used to evaluate the performance of each protocol. Significance testing of the performance differences was performed via 95% confidence intervals and non-inferiority tests. The differences in the area under the ROC curves were never more than 0.02 for the primary protocols. Non-inferiority was demonstrated between these protocols with respect to standard input techniques (all images selected and feature averaging). In conclusion, they showed that their automated lesion classification scheme is robust and can perform well when subjected to variations in user input.
database of biopsied lesions. Use of the UC CAD workstation resulted in an improvement of the performance of the all observers, as measured by means of a statistically significant increase in average Az value (0.80 to 0.85; p=0.0015) and partial Az value (0.11 to 0.25; p=0.0032), and sensitivity (0.82 to 0.87; p=0.0046) and positive predictive value (PPV) (0.66 to 0.69, p=0.047) calculated by patient biopsy management decision, as well as sensitivity (0.77 to 0.81; p=0.034) as calculated by BI-RADS score assessment. Although all increased after the use of CAD, they failed to show statistically significant differences in specificity as calculated by management (0.49 to 0.53; p=0.11) and BI-RADS assessment (0.45 to 0.47, p=0.30), and PPV as calculated by BI-RADS assessment (0.60 to 0.61; p=0.20). In conclusion, use of the UC MRI CAD workstation improved the performance of radiologists in the task of differentiating malignant and benign lesions at breast MRI. Thus the UC MR CAD workstation can be used as an aid to breast imaging radiologists in the interpretation of breast MRI (See Figure 33).

![Figure 33](image-url)

**Figure 33**

Interface of the Breast MRI CADx workstation illustrating output on a malignant case. The workstation automatically segments the tumor in 3D, determine the most enhancing voxels within the tumor along with the corresponding kinetic curve, calculates various morphological and kinetics features, and outputs an estimate of the probability of malignancy.

Pre-Clinical Evaluation of a Computerized System for Lesion Characterization in Breast DCE-MRI: Robustness Study and Correlation with BI-RADS Assessments

Weijie Chen, PhD, Maryellen Giger, PhD, Ken Chiang, Sanaz Jansen, and Gillian Newstead, MD, investigated their automatic and efficient computerized system for DCE-MRI breast lesion analysis, which includes assessment of tumor extent, extraction of lesion characteristics, and classification of the lesion in terms of an estimate of the probability of malignancy. The analysis involved two breast MR databases totaling 302 biopsy-proven lesions. T1-weighted SPGR sequence was used to acquire one precontrast series and 5 postcontrast series with a 1 min temporal resolution. The first database (77 malignant and 44 benign) was obtained with a 1.5T Siemens scanner. The second database (97 malignant and 84 benign) was from a 1.5T GE scanner. In the computerized lesion characterization, the identified breast lesions initially undergo automatic 3D segmentation by the computer. Then, characteristic kinetic curves are automatically identified. Image features are then automatically extracted to characterize the lesions as benign or malignant. Characteristic features include (1) kinetic features that quantify the uptake and washout characteristics of the contrast agent; (2) 3D texture features that quantify the uptake inhomogeneity within the lesion; and (3) 3D shape descriptors that quantify the irregularity of the tumor. A point biserial correlation method was used to investigate the correlation of computerized features with ACR BI-RADS assessments for breast MRI. A neural network model was used to merge multiple features into an estimate of the likelihood of malignancy. Statistical significant correlations (P<0.00001) were found between the computerized kinetic features extracted from automatically identified kinetic curves and BI-RADS assessments based on kinetic curves generated from ROIs drawn by expert radiologists. In addition, the neural network model for lesion classification yielded AUC values of 0.87 and 0.83 in independent testing of the two clinical databases, demonstrating robustness of the automatic analyses across two different MRI scanners. The online calculation time was approximately 10 seconds per MRI case. The automatic computerized analyses of breast MR images yielded high interpretation performances in the task of distinguishing between malignant and benign lesions, and the performance levels were similar across different MR scanners. This result is clinically relevant in that the MRI-CAD system has potential to improve both the efficiency and effectiveness of clinical breast MRI interpretation. Certain clinically time-consuming procedures could potentially be replaced by reliable automatic and efficient computerized procedures.

Prevalence Scaling: Applications to an Intelligent Workstation for the Diagnosis of Breast Cancer

Karla Horsch, PhD, Maryellen L. Giger, PhD, and Charles E. Metz, PhD, investigated the affect of changes that the prevalence of cancer in a population have on the probability of malignancy output and optimal operating points (optimal pair of TPF and FPF) of a mammographic and sonographic automatic classifier for the diagnosis of breast cancer. They investigated how a prevalence-scaling transformation used to change the prevalence inherent in the computer’s estimates of the probability of malignancy (PM) affects the numerical and histogram output of a previously developed multi-modality intelligent workstation. Using Bayes’ rule and the binormal
model, they studied how changes in the prevalence of cancer in the diagnostic breast population affect their computer classifiers’ optimal operating points, as defined by maximizing the expected utility. They found that prevalence scaling affects the threshold at which a particular TPF and FPF pair is achieved. They showed that histograms of PMs scaled to reflect clinically-relevant prevalence values differ greatly from histograms of laboratory-designed PMs. The optimal pair of TPF and FPF of their lower performing mammographic classifier was found to be more sensitive to changes in clinical prevalence than is that of their higher performing sono-graphic classifier. In conclusion, prevalence scaling can be used to change computer PM output to reflect clinically more appropriate prevalence. Relatively small changes in clinical prevalence can have large effects on the computer classifier’s optimal operating point.

**Volumetric Texture Analysis of Breast Lesions on Contrast-Enhanced Magnetic Resonance Images**

Automated image analysis aims to extract relevant information from contrast-enhanced magnetic resonance images (CE-MRI) of the breast and improve the accuracy and consistency of image interpretation. Weijie Chen, PhD, Maryellen L. Giger, PhD, Hui Li, PhD, Ulrich Bick, MD, and Gillian M. Newstead, MD, extended traditional 2D gray-level co-occurrence matrix (GLCM) method to investigate a volumetric texture analysis approach and apply it for the characterization of breast MR lesions. Their database of breast MR images was obtained using a T1-weighted 3D spoiled gradient echo sequence and consists of 121 biopsy-proven lesions (77 malignant and 44 benign). A fuzzy c-means clustering (FCM) based method was employed to automatically segment 3D breast lesions on CE-MR images. For each 3D lesion, a nondirectional GLCM was then computed on the first post-contrast frame by summing 13 directional GLCMs. Texture features were extracted from the nondirectional GLCMs and the performance of each texture feature in the task of distinguishing between malignant and benign breast lesions was assessed by receiver operating characteristics (ROC) analysis. Their results show that the classification performance of volumetric texture features is significantly better than that based on 2D analysis. Their investigations of the effects of various parameters on the diagnostic accuracy provided means for the optimal use of the approach.

**Power Spectral Analysis of Mammographic Parenchymal Patterns for Breast Cancer Risk Assessment**

Hui Li, PhD, Maryellen L. Giger, PhD, Olufunmilayo I. Olopade, MD, and Michael R. Chinander, PhD, evaluated the usefulness of power law spectral analysis on mammographic parenchymal patterns in breast cancer risk assessment. Mammograms from 172 subjects (30 women with the BRCA1/BRCA2 gene mutation and 142 low-risk women) were retrospectively collected and digitized. Because age is a very important risk factor, 60 low-risk women were randomly selected from the 142 low-risk subjects and were age matched to the 30 gene mutation carriers. Regions of interest were manually selected from the central breast region behind the nipple of these digitized mammograms and subsequently used in power spectral analysis. The power law spectrum analysis was evaluated for the mammographic patterns. The performance of exponent beta as a decision variable for differentiating between gene mutation carriers and low-risk women was assessed using receiver operating characteristic analysis for both the entire database and the age-matched subset. Power spectral analysis of mammograms demonstrated a statistically significant difference between the 30 BRCA1/BRCA2 gene mutation carriers and the 142 low risk women with average beta values of 2.92 (±0.28) and 2.47(±0.20), respectively. An AUC value of 0.90 was achieved in distinguishing between gene mutation carriers and low-risk women in the entire database, with an Az value of 0.89 being achieved on the age-matched subset. The BRCA1/BRCA2 gene mutation carriers and low-risk women have different mammographic parenchymal patterns. It is expected that women identified as high risk by computerized feature analyses might potentially be more aggressively screened for breast cancer.

**Image Analysis In Skeletal Imaging**

**Radiographic Texture Analysis in the Characterization of Trabecular Patterns in Periprosthetic Osteolysis**

Periprosthetic osteolysis is a disease attributed to the body’s reaction to fine polyethylene wear debris shed from total hip replacements. Joel R. Wilkie, PhD, Maryellen L. Giger, PhD, Charles A. Engh Sr., MD, Robert H. Hopper Jr., PhD, and John M. Martell, MD, investigated the ability of radiographic texture analysis (RTA) to characterize the trabecular texture patterns on pelvic images for osteolysis and normal total hip arthroplasty (THA) cases. Fourier-based and fractal-based texture features were calculated for a database of digitized radiographs from 202 THA cases, 70 of which developed osteolysis. The features were calculated from regions of interest selected at two time points: less than 1 month after surgery, and at the first clinical indication of osteolysis (or randomly selected follow-up time for normal cases). Receiver operating characteristic (ROC) analysis was used to compare feature performance at baseline and follow-up for osteolysis and normal cases. Separation between the RTA features for osteolysis and normal cases was negligible at baseline and increased substantially for
the follow-up images. The directional Fourier-based feature provided the best separation with an AUC value from ROC analysis of 0.75 for the follow-up images, in the task of distinguishing between normal and osteolytic cases. The results from this preliminary analysis indicate that qualitative changes in trabecular patterns from immediately after surgery to the eventual detection of osteolysis correspond to quantitative changes in RTA features. It therefore appears that RTA provides information that could potentially be useful to aid in the detection of this disease.

**Temporal Radiographic Texture Analysis in the Detection of Periprosthetic Osteolysis**

Periprosthetic osteolysis is one of the most serious long-term problems in total hip arthroplasty. It has been primarily attributed to the body’s inflammatory response to submicron polyethylene particles worn from the hip implant, and it leads to bone loss and structural deterioration in the surrounding bone. It was previously demonstrated that radiographic texture analysis has the ability to distinguish between osteolysis and normal cases at the time of clinical detection of the disease; however, that analysis did not take into account the changes in texture over time. Thus, Joel R. Wilkie, PhD, Maryellen L. Giger, PhD, Michael R. Chinander, PhD, Charles A. Engh, Sr., Robert H. Hopper, Jr., and John M. Martell assessed the ability of temporal radiographic texture analysis, tRTA, to distinguish between patients who develop osteolysis and normal cases. Two tRTA methods were used in the study: the RTA feature change from baseline at various follow-up intervals and the slope of the best-fit line to the RTA data series. These tRTA methods included Fourier-based and fractal-based features calculated from digitized images of 202 total hip replacement cases, including 70 that developed osteolysis. Results show that separation between the osteolysis and normal groups increased over time for the feature difference method, as the disease progressed, with area under the curve values from receiver operating characteristic analysis of 0.65 to 0.72 at 15 years postsurgery. Separation for the slope method was also evident, with AUC values ranging from 0.65 to 0.76 for the task of distinguishing between osteolysis and normal cases. The results suggest that tRTA methods have the ability to measure changes in trabecular structure, and may be useful in the early detection of periprosthetic osteolysis.

In coronary calcium scoring, motion artifacts affecting calcified plaques are commonly characterized using descriptive terms, which incorporate an element of subjectivity in their interpretations. Quantitative indices may improve the objective characterization of these motion artifacts. Thus, Martin King, PhD, Maryellen L. Giger, PhD, Kenji Suzuki, PhD, and Xiaochuan Pan, PhD, developed an automated method for generating 12 quantitative indices, i.e., features that characterize the motion artifacts affecting calcified plaques. This method consists of using the rapid phase-correlated region-of-interest tracking algorithm for reconstructing ROI images of calcified plaques automatically from the projection data obtained during a cardiac scan, and applying methods for extracting features from these images. The 12 features include two dynamic, six morphological, and four intensity-based features. The two dynamic features are three-dimensional velocity and 3D acceleration. The six morphological features include edge-based volume, threshold-based volume, sphericity, irregularity, average margin gradient, and variance of margin gradient. The four intensity-based features are maximum intensity, mean intensity, minimum intensity, and standard deviation of intensity. The 12 features were extracted from 54 reconstructed sets of simulated four-dimensional images from the dynamic NCAT phantom involving six calcified plaques under nine heart rate/multi-sector gating combinations. In order to determine how well the 12 features correlated with a plaque motion index, which was derived from the trajectory of the plaque, partial correlation coefficients adjusted for heart rate, number of gated sectors, and mean feature values of the six plaques were calculated for all 12 features. Features exhibiting stronger correlations with the motion index were 3D velocity, maximum intensity, and standard deviation of intensity. Features demonstrating stronger correlations with other features mostly involved intensity-based features. Edge-based volume/irregularity and average margin gradient/variance of margin gradient were the only two feature pairs out of 12 with stronger correlations that did not involve intensity-based features. Automatically extracted features of the motion artifacts affecting calcified plaques in cardiac computed tomography images potentially can be used to develop models for predicting image assessability with respect to motion artifacts.

**Computerized Assessment of Motion-Contaminated Calcified Plaques in Cardiac Multidetector CT**

Martin King, PhD, Maryellen L. Giger, PhD, Kenji Suzuki, PhD, Dianna ME Bardo, MD, Brent Greenberg, MD, Li Lan, MS, and Xiaochuan Pan, PhD, presented an automatic method for assessing the image quality of calcified plaques with respect to motion artifacts in noncontrast-enhanced cardiac computed tomography images. This method involves using linear regression (LR) and artificial neural network (ANN) regression models for predicting two patient-specific, region-of-interest-specific, reconstruction-specific and temporal phase-specific image

*Image Analysis In Cardiac Imaging*

**Feature-Based Characterization of Motion-Contaminated Calcified Plaques in Cardiac Multidetector CT**

Calcified Plaques in Cardiac Multidetector CT

Feature-Based Characterization of Motion-Contaminated Calcified Plaques in Cardiac Multidetector CT

Feature-Based Characterization of Motion-Contaminated Calcified Plaques in Cardiac Multidetector CT
quality indices. The first is a plaque motion index, which is derived from the actual trajectory of the calcified plaque and is represented on a continuous scale. The second is an assessability index, which reflects the degree to which a calcified plaque is affected by motion artifacts, and is represented on an ordinal five-point scale. Two sets of assessability indices were provided independently by two radiologists experienced in evaluating cardiac CT images. Inputs for the regression models were selected from 12 features characterizing the dynamic, morphological, and intensity-based properties of the calcified plaques. Whereas LR-velocity (LR-V) used only a single feature (three-dimensional velocity), the LR-multiple (LR-M) and ANN regression models used the same subset of these 12 features selected through stepwise regression. The regression models were parameterized and evaluated using a database of simulated calcified plaque images from the dynamic NCAT phantom involving nine heart rate/multi-sector gating combinations and 40 cardiac phases covering two cardiac cycles. Six calcified plaques were used for the plaque motion indices and three calcified plaques were used for both sets of assessability indices. In one configuration, images from the second cardiac cycle were used for feature selection and regression model parameterization, whereas images from the first cardiac cycle were used for testing. With this configuration, repeated measures concordance correlation coefficients (CCCs) and associated 95% confidence intervals for the LR-V, LR-M, and ANN were 0.817 (0.785, 0.848), 0.894 (0.869, 0.916), and 0.917 (0.892, 0.936) for the plaque motion indices. For the two sets of assessability indices, CCC values for the ANN model were 0.843 (0.791, 0.877) and 0.793 (0.747, 0.828). These two CCC values were statistically greater than the CCC value of 0.689 (0.648, 0.727), which was obtained by comparing the two sets of assessability indices with each other. These preliminary results suggest that the variabilities of assessability indices provided by regression models can lie within the variabilities of the indices assigned by independent observers. Thus, the potential exists for using regression models and assessability indices for determining optimal phases for cardiac CT image interpretation.

Image Analysis In Histological Images

Development of Computer-Aided Detection of Prostate Cancer in Histology Images

Graduate student Yahui Peng and Yulei Jiang, PhD, collaborating with clinical pathologists at Northwestern University and the University of Chicago, have been developing computer-aided diagnosis (CAD) methods for prostate cancer in histology images. While most work in the development of CAD has been aimed at helping radiologists diagnose cancers more accurately, their work aims at helping pathologists diagnose prostate cancer more accurately. They have developed a computer technique to recognize adenocarcinoma of the prostate in histology sections processed with an immunohistochemistry staining technique known as a triple antibody cocktail (AMACR/p63/34_E12). This staining technique labels malignant prostate epithelial cells red, and benign basal cells brown, making it easier for pathologists to identify the presence of malignant epithelial cells and the presence of benign basal cells crucial for the diagnosis of prostate adenocarcinoma. The computer technique further simplifies this detection task and automatically recognizes the presence of red and brown colors corresponding to these diagnostic features. In a blinded study of more than 300 images, they report sensitivity of the computer technique between 85% and 88%, and specificity between 89% and 97%, depending on the diagnostic subcategories of the cases. Further development of the
Image & Technology Evaluation

A Critical Analysis of the Clinical Studies Measuring the Effectiveness of Computer-Aided Detection in Screening Mammography

There have been ten clinical studies on CADe used in screening mammography. The results have been mixed. Robert M. Nishikawa, PhD, and Lorenzo Pesce, PhD, have critically evaluated the studies to determine why discrepancies exist. They examined the different methodologies used in the eight studies to identify sources of bias. Two different methods were used to measure the effectiveness of CADe. One was to compare the cancer detection rate between two time periods before and after CADe was implemented. The second was for a given radiologist determine how many extra cancers are detected because CADe was used. The two different methods can lead to different results, with the differences due in part to differences in biases. There are three large sources of variation that makes it difficult to measure the effectiveness of CADe. The first is intra-reader variability; the second inter-reader variability; and the third is the variation in the number of women presenting with cancer at screening. In spite of these sources of variability, using the six studies without significant biases, CADe can decrease the missed cancer rate by 9.7% with an increase in the recall rate of 13%. Measuring the clinical effectiveness of CADe in screening is difficult with a number of subtleties that are often overlooked by investigators. While each individual study is small (statistically speaking), the aggregate of the studies indicate that the performance of CADe is comparable to double reading by two radiologists. The researchers are now preparing a meta-analysis of CADe in screening mammography. While there are contradictory results from the different clinical study, most differences are result of methodological shortcomings and reader and patient variability. Since radiologists are most often the ones designing and conducting the studies, it is important for them to understand how to perform the studies properly.

Potential Effect of Different Radiologist Reporting Methods on Studies Showing Benefit of CAD

Karla Horsch, PhD, Maryellen Giger, PhD, and Charles E. Metz, PhD investigated the effect of different reporting methods and performance measures on the assessment of the benefit of computer-aided diagnosis (CAD) in characterizing malignant and benign breast lesions on mammography and sonography. In a previous study, ten observers provided three types of reporting data (probability of malignancy [PM] estimates, Breast Imaging Reporting and Data System [BI-RADS] ratings, and biopsy decisions), both without and with CAD. The current study compares alternative performance measures computed from the three types of reporting data. The area under the receiver operating characteristic curve (AUC) was computed from both the PM estimates and the BI-RADS ratings, whereas sensitivity and specificity were computed from all three data types. Sensitivity and specificity values calculated from either the PM estimates or the BI-RADS ratings were determined by setting both constant and user-dependent thresholds. Student’s t-tests were used to evaluate the statistical significance of the differences in the performance measures without and with CAD. The average AUC values of the ten observers calculated from either PM estimates or BI-RADS ratings demonstrated statistically significant improvements in performance with CAD, increasing from 0.87 to 0.92 or 0.93, respectively. However, the statistical significance of improvements in sensitivity or specificity depended on the type of reporting data used. Use of different types of reporting data in the computation of sensitivity and specificity may result in different conclusions concerning the benefit of CAD. Meaningful determination of sensitivity and specificity from PM estimates require the use of user-dependent thresholds.

Quality Assurance for Expert-Defined “Truth” in CT Nodule Detection

Samuel G. Armato III, PhD, and Heber MacMahon, MD, are the local Principal Investigators of the NCI-sponsored Lung Image Database Consortium (LIDC), which is developing a public database of thoracic computed tomography (CT) scans as a medical imaging research resource. A key aspect of this database is the annotations assigned by LIDC radiologists to indicate lung nodules in the scans. Computer-aided diagnostic (CAD) systems fundamentally require the opinions of expert human observers to establish “truth” for algorithm development, training, and testing. The integrity of this “truth,” however, must be established before investigators commit to this “gold standard” as the basis for their research. The purpose of this study was to develop a quality assurance (QA) model as an integral component of the “truth” collection process concerning the location and spatial extent of lung nodules observed on CT in the LIDC public database. One hundred CT scans were interpreted by four radiologists through a two-phase process. For the first of these reads (the “blinded read phase”), radiologists independently identified and annotated lesions, assigning each to one of three categories: “nodule > 3mm,” “nodule < 3mm,” or “non-nodule > 3mm.”
For the second read (the “unblinded read phase”), the same radiologists independently evaluated the same CT scans but with all of the annotations from the previously performed blinded reads presented; each radiologist could add marks, edit or delete their own marks, change the lesion category of their own marks, or leave their marks unchanged. The post-unblinded-read set of marks was grouped into discrete nodules and subjected to the QA process, which consisted of (1) identification of potential errors introduced during the complete image annotation process (such as two marks on what appears to be a single lesion or an incomplete nodule contour) and (2) correction of those errors. Seven categories of potential error were defined; any nodule with a mark that satisfied the criterion for one of these categories was referred to the radiologist who assigned that mark for either correction or confirmation that the mark was intentional. A total of 105 QA issues were identified across 45 (45.0%) of the 100 CT scans. Radiologist review resulted in modifications to 101 (96.2%) of these potential errors. Twenty-one lesions erroneously marked as lung nodules after the unblinded reads had this designation removed through the QA process (See Figure 34).

A lesion marked as a “nodule > 3 mm” by three radiologists with no mark at all assigned by the fourth radiologist (category 6 error). As a result of the QA process, the fourth radiologist indicated that an error had been made and also marked this lesion as a “nodule > 3 mm.”

**Evaluation of Lesion Boundary and Area Definitions**

Samuel G. Armato III, PhD, and colleagues have been investigating the potential impact of inconsistent approaches to lesion size quantification. Measurement of the size of anatomic regions of interest in medical images is used to diagnose disease, track growth, and evaluate response to therapy. The discrete nature of medical images allows for both continuous and discrete definitions of region boundary. These definitions may, in turn, support several methods of area calculation that give substantially different quantitative values. This study investigated the possible impact of applying inconsistent definitions of region boundary and area to medical images for the purpose of computerized patient analysis by evaluating several boundary definitions (e.g., continuous polygon, internal discrete, and external discrete) and area calculation methods (pixel counting and Green’s Theorem). Region boundary definitions and area calculation methods were categorized as native to discrete space or native to continuous space.

These methods were applied to two separate databases: the Lung Image Database Consortium database of lung nodules (with region boundaries confined to discrete pixel space) and a database of adrenal gland outlines (with region boundaries defined in continuous space). Average percent differences in area on the order of 20% were found among the different methods applied. These results support the idea that inconsistent application of region boundary definition and area calculation may substantially impact measurement accuracy. Further, these differences also support the importance of reporting boundary definition and area calculation methods in written protocols and published manuscripts.

**Effect of Normal Breast Structure on Cancer Detection – Preliminary study**

Robert M. Nishikawa, PhD, and Ingrid Reiser, PhD, are studying the effects of appearance of normal breast anatomy on the detection of breast cancer. It is well known by radiologists that the superposition of normal breast tissue can obscure cancers (leading to a false negative) and can cause what appears as a cancer but in fact it is not (false positive). This is a fundamental limitation of mammography: the 3D breast is projected onto a 2D image. Breast tomosynthesis is an emerging technique that can produce a stack of 2D slices through the breast reducing the amount of tissue superposition. However, unlike CT, tomosynthesis scans the breast over only a small arc and not 360 degrees. As a result, there is still some residual tissue overlap. They conducted a study to quantify how much the breast structure is reduced in a tomosynthesis reconstructed slice compared to a conventional mammogram. There are two parameters that characterize the appearance of the breast structure. The beta parameter is a measure of the texture – the higher the beta the more pronounced the texture, which increases the chances of a false negative or false positive interpretation. The other parameter is the magnitude of the texture – higher magnitude the more likely the radiologist will make an error. Compared to mammography, beta is reduced from 3.06 to 2.87 (p<0.001) for a tomosynthesis slice. The magnitude parameter was reduced from 10.3 to 1.48 (p<0.001). The next step is to use model observers that mimic the performance of radiologists to predict what the effect of these changes are on breast cancer detection.

**Investigation of Bayesian Methods for ROC Analysis**

Graduate student Richard Zur, Lorenzo Pesce, PhD, Yulei Jiang, PhD, and Charles Metz, PhD, have been investigating Bayesian methods for receiver operating characteristic (ROC) analysis. The conventional method for ROC analysis is based on the statistical method of maximum-likelihood estimation (MLE). The statistical methods of Bayesian techniques have some fundamental differences from the MLE. One advantage of Bayesian methods is that they provide a formal mechanism for combining one set of experimental data with prior data, which in principle helps investigators collect experiment evidence more
efficiently. However, fundamental differences in methodology and interpretation between the two methods warrant careful analysis of both. Their work has shown that when applied under equal conditions and under identical assumptions, the Bayesian method generates similar results as the MLE in producing ROC curve fits. Modifying the prior assumptions used in the Bayesian method causes modifications in the ROC curve fits. In particular, a specific prior assumption that may be considered more reasonable than the corresponding assumption of the MLE results in small differences in most ROC curve fits compared with the MLE, but produces apparently more reasonable curve fits in "degenerate" ROC curves that the MLE produces mathematically perfect but not necessarily plausible fits because the data do not contain enough information to discern the height of the ROC curve under the method of MLE. More work on the analysis and application of Bayesian ROC analysis will continue.

Reliable and Computationally Efficient Maximum-Likelihood Estimation of “Proper” Binormal ROC Curves

Estimation of ROC curves and their associated indices from experimental data can be problematic, especially in multireader, multicase (MRMC) observer studies. Wilcoxon estimates of area under the curve (AUC) can be strongly biased with categorical data, whereas the conventional binormal ROC curve-fitting model may produce unrealistic fits. The “proper” binormal model (PBM) was introduced by Metz and Pan to provide acceptable fits for both sturdy and problematic datasets, but other investigators found that its first software implementation was numerically unstable in some situations. Therefore, Lorenzo Pesce, PhD, and Charles Metz, PhD, developed an entirely new algorithm to implement the PBM and tested it extensively on a broad variety of simulated and real datasets. The new algorithm never failed to converge and produced good fits for all of the several million datasets on which it was tested. For all but the most problematic datasets, the algorithm also produced very good estimates of AUC standard error. The AUC estimates compared well with Wilcoxon estimates for continuously distributed data and are expected to be superior for categorical data. Windows, Linux, and Apple Macintosh OS X versions of the new algorithm are available online at http://xray.bsd.uchicago.edu/kr1/.

Generalization of ROC Analysis to Classification Tasks that Involve More than Two Classes

A receiver operating characteristic (ROC) curve gives a complete description of an observer’s performance in a two-class classification task. When the observer must distinguish among three classes, his/her/its performance must, in general, be described by a five-dimensional surface in a six-dimensional ROC space. Because of this increase in complexity, many researchers have proposed restricted observer models whose performance can be described with two-dimensional surfaces in three-dimensional ROC spaces. Darrin Edwards, PhD, and Charles Metz, PhD, analyzed four such restricted models and showed that the observer which achieves optimal performance with respect to the chosen three-dimensional ROC space is in fact a restricted form of the so-called ideal observer. The ideal observer is the observer that obtains optimal performance in a general (unrestricted) classification task. There are two well-known methods for showing that the ideal observer is optimal: the Neyman-Pearson criterion and maximization of expected utility. During Drs. Edwards’ and Metz’s consideration of the four restricted cases just mentioned, they discovered that these two methods do not merely yield the same observer, but are in fact completely equivalent in a mathematical sense. This result has allowed them to prove that, for a wide variety of observers which achieve optimal performance with respect to a restricted ROC surface, the two-dimensional surface in three-dimensional ROC space that is determined by either method provides a complete description of observer performance in those restricted three-class classification tasks.

The Hodges Society had a solid, productive and effective year. Our talented departmental alumni continue to impress us with their skills and reach. The newest members of the Society were inducted informally along with other residents, fellows and staff at the annual June departmental celebration. The organization continues to provide funding for both for research efforts and for educational materials, and is also adding new ideas to achieve the department’s mission highlighted on our department’s updated website. Efforts continue to largely focus on training those who will provide not only excellence in patient care, but contribute to education and research.
This retrospective study included ten consecutive patients who had both carotid CTA and brain MRI. The carotid calcium volume on CTA was measured using a region-based thresholding method (See Figures 35 and 36). The intraobserver variability was evaluated. The mean ADC value of cerebral white matter on MRI was computed (See Figure 37).

Five patients had at least one visible carotid calcium plaque on CTA and concurrent small vessel ischemic disease on MRI. Among the five patients with no carotid plaque, two had small vessel ischemic disease, and the remaining three had normal-appearing white matter. The mean carotid calcium volume ranged from 0.035 to 0.212 cm. The mean intraobserver variability of the calcium volume measurement was 4.2% for an individual plaque and 2.9% for the plaques combined. The mean ADC value of white matter tended to increase in patients with small vessel ischemic disease.

With this preliminary study, the algorithms of the measurements of the ADC value of white matter and the volume of the carotid calcium have been established. Future investigation will explore associations between the ADC values and the calcium volume and the risk.
factors upon an increase in sample size to achieve a statistical power. The ultimate clinical significance of this research could be very great. Upon the success of this research, the data could be helpful in future clinical trials and strategies for prevention of stroke. Information gained from this research would also reinforce the need for imaging in the risk assessment and reflect a further evolution to global risk assessment strategy for systemic diseases.

A special thanks to the Paul C. Hodges Alumni Society for its generosity and interest in funding this project, which has provided great support and encouragement for both my colleagues and me.

Society Members: Please remember to send any address or email changes to Thelma Wright, University of Chicago, Department of Radiology, 5841 S. Maryland Avenue, MC2026, Chicago, IL 60637.

You may also send changes via fax to 773-702-2523 or email at pchodges@radiology.bsd.uchicago.edu. Society business questions may be directed to Dr. Christopher Straus at the address listed above, or via email to cstraus@uchicago.edu. Donations may be made using the enclosed envelope.

Educational Programs

Fellowship Programs

Abdominal Imaging

The Abdominal Imaging Fellowship is a one-year comprehensive fellowship comprising clinical, teaching, and research activity in all aspects of abdominal imaging using all available modalities, including dedicated MRI rotations. The clinical experience combines a regional population of patients providing a strong base of emergency and primary presentation exams with a strong outpatient and inpatient tertiary referral center providing a high volume of oncology, surgery, gastroenterology, transplantation and emergency referrals. CT focuses on problem solving, detailed and tailored examinations, such as multiphase hepatic CT, renal and adrenal mass characterization and negative contrast luminal examinations. Fellows will learn to perform and interpret 3D CT angiography, CT enterography, CT urography, CT colonography and other cutting-edge diagnostic studies.

The MRI experience includes dedicated liver, pancreas, adrenal, renal and pelvic imaging including MR angiography, cholangiography, prostate MRI, MR enterography and fetal MRI. This rotation also affords the fellow the opportunity to participate in non-abdominal applications if desired.

Ultrasound offers the gamut of abdominal studies, small parts ultrasound, and percutaneous biopsies, as well as color and spectral Doppler vascular and transplant studies. Fellows have the opportunity to gain additional expertise in vascular ultrasound and ob-gyn ultrasound as needed. Fellows can participate in a wide gamut of gastrointestinal and genitourinary examinations.

Our cutting edge equipment includes six superconducting magnets, with a second 3.0T magnet to be installed this year, six multislice helical CT scanners, including 64 slice capability (and a 256 slice scanner to be installed this year), an all Acuson/Siemens ultrasound area and digital fluoroscopy.

Fellows participate in resident teaching and are encouraged to participate in research and publication by either joining ongoing projects or initiating a new project with a faculty mentor and dedicated academic time.

ADC map (Left): A total of 6 ROIs were symmetrically placed on the periventricular white matter to compute the ADC values; Diffusion weighted image (Right): an acute stroke in the right posterior parietal lobe.
Musculoskeletal Fellowship
The Musculoskeletal Fellowship is a one year program that began July 1, 1999; thus far, seven individuals have completed the program since inception. Prerequisites for the program include completion of a residency in Radiology as well as selective criteria, such as an interest in both clinical and academic MSK radiology. Good letters of reference from the residency program director and other faculty members are essential. Finally a personal interview day with the candidate is mandatory. The section has successfully recruited top residents from our own radiology residency programs as well as from other nationally recognized programs such as Stanford, the Brigham, and Emory University.

The goal of the program is to train a radiologist in all aspects of clinical MSK radiology as well as to promote academic radiology interest. Each fellow participates in case reading sessions four days a week with the fifth day for academic interest. Participation is expected in the weekly orthopedic oncology and weekly rheumatology conferences. Formal conferences in musculoskeletal are offered every week and there is a weekly case conference in the section. Fellows are expected to prepare conferences for residents, and to have projects leading to publications. The fellow is also expected to perform procedures including biopsies, arthrograms, and RFAs, as well as supervise and train radiology residents.

Vascular and Interventional Radiology Fellowship
The Vascular and Interventional Radiology Fellowship is a one-year comprehensive program, the goal of which is to provide in-depth clinical, teaching and research experience in all aspects of both adult and pediatric angiography and interventional procedures. Fellows perform Interventional Radiology procedures and provide clinical care of patients under the daily supervision of full-time faculty members. In addition to reading CT and MR angiographic studies, fellows perform vascular and non-vascular procedures using sonographic, fluoroscopic and CT guidance. Education of fellows is performed through a combination of clinical experience in the Interventional Radiology suites, didactic teaching during film interpretation procedure review sessions, attendance at multidisciplinary conferences, attendance of monthly meetings with review of morbidity and mortality cases, and attendance of lectures provided by the faculty.

Essential to their educational development, the Vascular and Interventional Radiology fellows are central components in the day-to-day clinical management of the VIR section at the University of Chicago. The VIR section is unique in the Radiology department in that it is entirely a clinical service, performing patient consultations, history taking, physical examinations, inpatient rounds, patient consents, physician consultations, procedures, post-procedure care and patient follow-up. The fellows are not just trainees, but represent an integral part of this clinical management, communicating with referring physicians, coordinating patients through the section, overseeing patient care, and performing clinical rounds and follow-up. The fellows are expected to participate actively in ongoing scholarly projects under the supervision of the faculty members. This work should result in publication in refereed or educational journals and presentation at institutional, regional or national scientific meetings in accordance with ACGME recommendations.

In addition to these clinical responsibilities, the fellows obtain in-depth teaching and research experience by preparing and providing resident conferences and directly participating in quality assurance, educational, and research projects ongoing within the section.

The program is accredited by the ACGME for three positions per year and, depending on the year, offers either two or three of these positions in the annual match. The section has hired two fellows for 2008-9 and two fellows for 2009-10.

Diagnostic Radiology Residency
The Department of Radiology’s mission is to provide outstanding training in diagnostic radiology which will prepare residents for future careers in academic radiology or full-time clinical practice.

Our basic four-year residency training program, supported by clinical and research-oriented fellowships, is well balanced and offers excellent preparation for a broad variety of career pathways including academic careers, general radiology and subspecialty practice in both academic and private practice.

The residency program has increased in size for each of the past three years and will reach our new full complement of 28 residents for the 2007-2008 academic year. The increase has allowed us to provide additional rotations in cardiac imaging, mammography and PET imaging among others. It will also allow us the flexibility to offer new programs for incoming residents with research interest.

This past year has been very successful with numerous resident publications and honors:
Presentations

Buckle, CE, Castillo, M: Use of DWI to Evaluate the Initial Response of Progressive Multifocal Leukoencephalopathy to Highly Active Antiretroviral Therapy: Early Experience Presented at ASNR 06/2008


Awards

R. Evan Nichols, MD
Weiss Hospital Award (Outstanding Clinical Work at Weiss Hospital), 2008

Christopher Buckle, MD
Neuroradiology Award (Outstanding Performance in Neuroradiology), 2008

Danny Cheng, MD
Chien Tai Lu Award (Outstanding Clinical Work in Vascular Interventional Radiology), 2008

Golden Tip Award (Outstanding Performance in Gastrointestinal Radiology), 2008

Nicholas Krause, MD
Golden Tip Award (Outstanding Performance in Gastrointestinal Radiology), 2008

In January 2008, Gregory Henkle and Sheela Konda were chosen as co-chief residents and will serve until January 2009.

Departing Residents

The residency program has had yet another successful year. Seven residents graduated, with seven pursuing fellowships and three continuing at the University of Chicago:

- Colin Brown, MD, completed his medical education at the University of Iowa and his PGY1 at Carraway Methodist Medical Center;
- Andrew Hall, MD, completed his medical education at the University of Pittsburgh and his PGY1 at the University of Chicago;
- Rony Kampalath, MD, completed his medical education at the University of Texas and his PGY1 at the University of Chicago;
- Aswin Krishnamoorthy, MD, completed his medical education at the University of Illinois and his PGY1 at Weiss Hospital;
- Avnit Kapur, MD, completed his medical education at the University of Illinois and his PGY1 at the University of Chicago;
- Valeria Potigailo, MD, completed her medical education at Johns Hopkins and her PGY1 at West Suburban Medical Center;
- Joseph Yacoub, MD, completed his medical education at Wake Forest University and his PGY1 at the University of Chicago.

Incoming Residents

We are pleased to welcome eight new residents for the 2008-2009 academic year in the hope that they will discover the unique program of study that our department has to offer. We are confident that they will make excellent residents.

These residents began their training on July 1, 2008:
- Parag Amin, MD, completed his medical education at the University of Virginia and his PGY1 at Cornell University;
- Colin Brown, MD, completed his medical education at the University of Iowa and his PGY1 at Carraway Methodist Medical Center;
- Andrew Hall, MD, completed his medical education at the University of Pittsburgh and his PGY1 at the University of Chicago;
- Rony Kampalath, MD, completed his medical education at the University of Texas and his PGY1 at the University of Chicago;
- Aswin Krishnamoorthy, MD, completed his medical education at the University of Illinois and his PGY1 at Weiss Hospital;
- Avnit Kapur, MD, completed his medical education at the University of Illinois and his PGY1 at the University of Chicago;
- Valeria Potigailo, MD, completed her medical education at Johns Hopkins and her PGY1 at West Suburban Medical Center;
- Joseph Yacoub, MD, completed his medical education at Wake Forest University and his PGY1 at the University of Chicago.
Medical student education has undergone some significant changes recently. Building on the momentum of the changes in the Human morphology course made last year their involvement in the first two years of medical school increases again. A large improvement has been noted, including in medical student boards part I scores.

The program will now begin to include key imaging in the spring neuro anatomy course and make measured progress in incorporating imaging into the key MS II course Clinical Pathophysiology and Treatment. This will mean that nearly every course the student takes in their first two years will have radiology imaging as part of the content, much of it taught by radiologists; students will also have access and exposure to radiology staff throughout this time.

We continue to provide outreach in the form of small research grants which involve students through the Radiology Research and Opportunity Program (RROP). This makes smaller funds available for projects which involve students on a short turn around basis (usually two days) and with a short simple one page application. This was developed to ensure that money was available for equipment as the need arose and not allow the shorter windows of opportunity most students allow to close when an interest is expressed.

We have since restructured our senior elective and have received positive feedback from not only our medical students but also students from other institutions. Our faculty has created dedicated lectures which are specific to the student’s needs and interests. Students will spend time each week in a different subspecialties observing and learning. Residents are now playing a larger role by serving as mentors that assist the student with a case study which they will present.

As the year ended the discussion and next major change was discussed and adopted. This includes the restructuring of the senior elective to one which has equivalent flexibility but also provides more structure and role for our senior students while on this elective tract. The changes will include dedicated lectures for students, computer access and teaching files and a focus that will stress the importance of radiology imaging in overall patient care. These new changes will be in development over the following summer and implemented towards the start of the new year. These major changes continue to demonstrate the need and augment the core experiences which help motivate many who choose our specialty as a career but also supplement our mission of additionally steering many into academics and leaving others who choose other fields of study to understand and use our resources effectively.

The Graduate Programs in Medical Physics are under the Committee on Medical Physics at the University of Chicago and offers research training at three levels that lead to the Master of Science degree and to the Doctor of Philosophy degree, and provide postdoctoral training. Faculty on the Committee come from the Departments of Radiology and Radiation & Cellular Oncology. Maryellen Giger, PhD, is Chair of the Committee and represents its faculty within the BSD Basic Science Chairs. Primary areas of research interest by the program faculty include the Physics of Diagnostic Radiology, Physics of Nuclear Medicine/Molecular Imaging, Physics of Magnetic Resonance Imaging, and Physics of Radiation Therapy. Unique features of this CAMPEP-Accredited program are the faculty’s focused effort on research in medical imaging and on the training of high-level medical physicists. We have 30 pre-doctoral students and six post-doctoral trainees. A continuing NIH training grant funds four pre-doctoral students and two post-doctoral fellows in the training of medical physics. Additional funding has been obtained from the U.S. Army, the BSD, the UCCRC and the Lawrence Lanzl Fund. Currently 10 of our 30 students have been awarded US Army Pre-doctoral fellowships for their dissertation research.

Current post doctoral fellows are:

- Hee Jong Kim, PhD, from Yonsei University, who is working under the supervision of Chien-Min Kao, PhD, and conducting research on the early digitization of the PET signal and its greater advantages than the typical PET signal processing method. The multi-threshold method is one of the ways to achieve this goal by applying the different threshold to the signal from the photo detector. With the guidance of Dr. Kao, they are developing the multi-threshold discriminator board in
collaboration with the Physics department’s electronics group to implement the idea. The various tests on the board show promise and the efficient readout scheme for the digitized signal is being investigated in collaboration with Fermi lab and Physics Department. Silicon Photomultiplier (SiPM) is a promising photodetector as a substitute to the long lasting Photomultiplier Tube (PMT) in PET detector in terms of compactness and low operation voltage. SiPM’s insensitivity to magnetic fields is also an attractive characteristic for a PET/MRI development. A PET detector design using the SiPM as a photo-device is under study.

• Ji Li, PhD, from Renseselaer Polytechnic is working under the supervision of Bulent Aydogan, PhD, conducting research on developing a novel CT contrast agent. This field of research has drawn great attention in recent years. Successful completion of this project could potentially change the landmarks of medical imaging. This is a joint research project between the University of Chicago and the Argonne National Laboratory. Our ANL User Proposal was accepted by the ANL review committee in September 2008 with an “Excellent Rating”. Several preliminary experiments have been conducted with promising results.

Current post doctoral scholars are:

• Michael Chinander, PhD, from the University of Chicago is working under the supervision of Maryellen Giger, PhD, conducting research on non-invasive measurement of the temporal wear of total hip arthroplasty components from radiographic images. He also investigates the assessment of bone quality and osteoporosis using radiographic texture analysis of heel bone densitometry images. Mike is also conducting research in the radiographic risk assessment of slipped capital femoral epiphysis (SCFE) using mechanical analysis of hip joint force components.

• Lara Leoni, PhD, from the University of Illinois at Chicago, works under the supervision of Brian Roman, PhD, conducting research on functional magnetic resonance imaging of pancreatic islets. Human pancreatic islet transplantation is currently being performed around the world to cure diabetes. Lara has demonstrated that MRI can be used to image pancreatic islets which have been activated by glucose stimulation and can be detected on a T1-weighed MR image. She has applied this approach to rodent and human islets in-vitro and is currently applying this technique in in-vivo rodent models of transplanted islets.

• Margo Levine, PhD, from Northwestern University, is working under the supervision of Xiaochuan Pan, PhD, conducting research on addressing the issue of data redundancy in image reconstruction algorithms through the derivation and implementation of consistency conditions for CT data.

• Guihua Zhai, PhD, from the University of North Carolina at Chapel Hill, is working under the supervision of Jia-Hong Gao, PhD, conducting research on understanding the physiological mechanism of the brain function in the actions of glucose and alcohol. Cerebral blood flow based brain maps will be generated using functional MRI and the results will be compared with the neuronal activities in the hypothalamic region and other parts of the brain.

Current pre-doctoral students are:


We expect four new pre-doctoral students to join us in the autumn of 2008. They are Martin Andrews (University of Illinois at Chicago), Xia Jiang (Washington State University), Kevin Little (Taylor University), and Federico Pindeda (Carnegie-Mellon University).

2007-2008 Graduates

Five students received their PhD's during the academic year. They were:

Michalis Aristophanous (Charles Pelizzari, PhD, Advisor) “Definition of tumor volume from positron emission tomography for radiation treatment of patients with non-small cell lung cancer.”

Joshua Haslam (John Roeske, PhD, Advisor) “Analysis of geometric uncertainties in women treated with intensity modulated whole pelvic radiation therapy for gynecologic malignancies.”

Martin King (Maryellen Giger, PhD, Advisor) “Feature-based characterization and image quality optimization of
motion-contaminated coronary structures in cardiac CT images.”

Chisako Muramatsu (Kunio Doi, PhD, Advisor) “Investigation of similarity measures for selection of similar images in computer-aided diagnosis of breast lesions on mammograms.”

Laura Yarusso (Robert Nishikawa, PhD, Advisor) “The effect of image quality on computer-aided diagnosis in digitized screen-film and full-field digital mammography.”

Awards received within the past year by current pre-doctoral students:

Michael Altman:
• Army Predoctoral Prostate Cancer Research Award, Department of Defense (2008).

Sanaz (Sunny) Arkani Jansen:

Michalis Aristophanous:
• Student Travel Grant Award, SPIE Medical Imaging Conference (2008).

Neha Bhooshan:
• Young Investigator’s Symposium Finalist, AAPM (2008).

Junguo Bian:
• Army Predoctoral Breast Cancer Research Award, Department of Defense (2008).
• Student Trainee Award, IEEE NSS-MIC (2008).

Seungryong Cho:
• Student Travel Grant Award, IEEE NSS-MIC (2007).

Sean Foxley:
• Radiological Society of North America (RSNA) Trainee Research Prize for RSNA (2008).
• Educational Travel Stipend Sixteenth Scientific Meeting and Exhibition of ISMRM (2008).

Xiao Han:
• Student Travel Grant Award, IEEE NSS-MIC (2007).
• Student Travel Grant Award, IEEE NSS-MIC (2008).

Andrew Jamieson:
• Army Predoctoral Breast Cancer Research Award, Department of Defense (2008).

Martin King:
• Radiological Society of North America (RSNA) Trainee Research Prize for RSNA (2007).

Beverly Lau:
• Army Predoctoral Breast Cancer Research Award, Department of Defense (2007).
• Student Travel Award, MIPS Conference (2007).
• Cum Laude Poster, SPIE (2008).

Dimple Modgil:
• Army Predoctoral Breast Cancer Research Award, Department of Defense (2008).

Erik Pearson:
• Young Investigator’s Award, AAPM (2008).

Yahui Peng:
• Travel Grant Recipient from the University of Chicago Women’s Board (2007).

William Sensakovic:
• IEEE Nuclear Sciences Symposium and Medical Imaging Conference (2008).
• Doolittle-Harrison Fellowship, University of Chicago (2008).

Abbie Wood:
• ISMRM New Entrant Stipend Award (2007).

Dan Xia:
• Student Travel Award, IEEE Medical Imaging Conference (2008).

Yading Yuan:
• Women’s Board Travel Award in the Division of the Biological Sciences, The University of Chicago (2008).

Peer-reviewed journal publications within the past year by our pre-doctoral students:


X. Han, D. Xia, E. Sidky, X. Pan: Noise properties of the discrete finite Hilbert transform (submitted 2008).


Proceding papers within the past year by our pre-doctoral students:


Presentations and abstracts within the past year by our pre-doctoral students


M. Aristophanous, C. Pelizzari: A mixture model based technique for PET tumor volume segmentation with minimal user interaction. SPIE Medical Imaging 2008.


X. Han, S. Cho, W-X. Song, T-C He, X. Pan: Micro-CT imaging and quantitative characterization of bone morphogenetic protein regulated differentiation of mesenchymal stem cells. AAPM 2007.


E. Pearson, S. Cho, X. Pan, C. Pelizzari: Region of interest imaging in CBCT for radiation therapy. AAPM 2008


P. Seifi, B. Epel, S. Sundramoorthy, C. Mailer, H. Halpern: Multiple stepped magnetic field technique applied to enhance the resolution of electron spin echo oxygen imaging (ESEOI) at 250MHz. AAPM 2008.

P. Seifi, B. Epel, C. Mailer, H. Halpern: Simulation of time domain EPR imaging at 250MHz and applications to high resolution multiple B scheme in electron spin echo oxygen imaging. Rocky Mountain Conference on Analytical Chemistry 2008.


Honors & Awards

Paul Chang, MD

Abraham Dachman, MD
• Radiology Editor’s Recognition Award.

Maryellen Giger, PhD
• Named Director, Imaging Research Institute, University of Chicago, Chicago, Illinois.

Chien-Min Kao, PhD
• Senior Member, Institute of Electrical and Electronics Engineers.

MG Knuttinen, T Van Ha, C Reilly, et al.

Patrick La Rivière, PhD
• Kurt Rossmann Award for Excellence in Teaching, Graduate Programs in Medical Physics, The University of Chicago, October 2007.

Heber MacMahon, MD
• Elected President, Fleischner Society.

Robert Nishikawa, PhD

Aytekin Oto, MD

Xiaochuan Pan, PhD
• Fellow, American Institute of Medical and Biological Engineering.
• Fellow, Optical Society of America.

David Paushter, MD
• Fellow, the American College of Radiology.
• Radiology Editor’s Recognition Award.

G. Scott Stacy, MD
• James W. Ryan Senior Class Teaching Award, Department of Radiology, The University of Chicago, Chicago, IL, 2007.

Christopher Straus, MD
• Selected by the Pritzker School of Medicine Class of 2008 as one of the top ten teachers.

Kenji Suzuki, PhD
• Listed in Marquis Who’s Who in Science and Engineering.
• Listed in Marquis Who’s Who of Emerging Leaders.

Society Offices & Committees

American Association of Physicists in Medicine
Samuel Armato, PhD
Member, Journal Business Management Committee
Member, Education and Training of Medical Physicists Committee
Member, Computer-Aided Detection in Diagnostic Imaging (CAD) Subcommittee

Maryellen Giger, PhD
Elected, President-Elect of AAPM and Board Member
Robert Nishikawa, PhD  
Chair, Research Subcommittee  
Member, Physics Committee  
Member, Science Council  
Member, RSNA Education Coordination Subcommittee

Xiaochuan Pan, PhD  
Symposium Chair, Annual Meeting

American Board of Radiology  
Daniel Appelbaum, MD  
Maintenance of Certification (MOC) Committee in Nuclear Medicine

G. Scott Stacy, MD  
Member, Subcommittee on Practice Guidelines and Technical Standards for Radiography of Extremities in Adults and Children

American College of Radiology  
Abraham Dachman, MD  
Media spokesperson  
Member, Colorectal Cancer Committee  
Member, Subcommittee on Colon Cancer Screening  
Member, Subcommittee on CT Colonography Metrics  
Member, Virtual Colonoscopy Screening Panel

Kate Feinstein, MD  
Member, Commission on Pediatric Radiology  
Member, Committee on Drugs and Contrast Media  
Member, Committee on Economics (Commission on Ultrasound)  
Member, Continuing Profession Improvement, Expert Panel on Pediatric Radiology

Brian Funaki, MD  
Chairman, Appropriateness Committee Expert Panel on Interventional Radiology

Jonathan Lorenz, MD  
Member, Expert Panel on Interventional Radiology

Heber MacMahon, MD  
Member, Appropriateness Standard Committee

David Paushter, MD  
Member, CT Accreditation Committee  
Member, Economics Committee, Abdominal Imaging Ultrasound Credentialing Site Reviewer

American College of Radiology Imaging Network (ACRIN)  
Abraham Dachman, MD  
Member, Publications Committee

Heber MacMahon, MD  
Member, National Lung Screening Trial Computer Aided Diagnosis Working Group

Robert Nishikawa, PhD  
Member, Breast Committee  
Member, Digital Mammography Screening Trial - Executive Committee  
Member, Informatics Committee

American Institute of Ultrasound in Medicine  
David Paushter, MD  
Chair, Clinical Standards Committee

American National Standards Institute Medical Devices Standard Management Board  
Paul Chang, MD  
Representative (from RSNA)

American Roentgen Ray Society  
Abraham Dachman, MD  
Member, CME Evaluations Subcommittee

Brian Funaki, MD  
Associate Chair, 2008 Program Committee  
Chairman, 2008 Annual Meeting Instructional Course Committee (Vascular and Interventional Radiology)  
Co-Director, 2008 Annual Meeting Approach to Diagnosis: Case Based Imaging Review Course  
Member, Self Assessment Module Subcommittee

Jonathan Lorenz, MD  
Coordinator, Moderator, and Lecturer, Abscess Workshops, Annual Meeting  
Judge, Electronic Exhibits, 2008 Annual Meeting  
Member, Interventional Radiology Subcommittee

Gillian Newstead, MD  
Member, Program Review Committee  
Member, Scientific Education Subcommittee

Ibericoamerican Society of Interventionism  
Mario Zaritzky, MD  
Co-editor, Intervencionismo (Scientific Journal)

Illinois Radiological Society  
Abraham Dachman, MD  
Executive Committee

Kate Feinstein, MD  
President

Institute of Electrical and Electronics Engineers  
Chien-Min Kao, PhD  
Member, Technical Committee, IEEE Nuclear Science Symposium and Medical Imaging Conference

Xiaochuan Pan, PhD  
Member, Scientific Program Committee, Symposium on Medical Imaging and Augmented Reality  
Member, Technical Program Committee, IEEE Medical Imaging Conference
Institute of Electrical and Electronics Engineers in Medicine and Biology
Chien-Min Kao, PhD
Associate Editor, Conference

Xiaochuan Pan, PhD
Theme Chair, Annual Meeting
Track Chair, Annual Meeting

Kenji Suzuki, PhD
Reviewing Panelist, Senior Member Application Review Panel

International Conference on Machine Learning and Applications
Kenji Suzuki, PhD
Member, Program Committee, Special Session on Applications of Machine Learning in Radiotherapy

International Conference on Pattern Recognition
Kenji Suzuki, PhD
Member, Reviewing Committee

International Conference on Smart Homes and Health Telematics
Kenji Suzuki, PhD
Member, Reviewing Committee

International Symposium on Computational Intelligence and Industrial Applications
Kenji Suzuki, PhD
Member, Program Committee

MedBiquitous
Paul Chang, MD
Member, Standards Committee (from RSNA)

National Cancer Institute
Heber Macmahon, MD
Member and Investigator, Lung Image Database Consortium

Organization for Human Brain Mapping
Jia-Hong Gao, PhD
Member, Organizing Committee Annual Meeting

Radiological Society of North America
Samuel Armato, PhD
Member, Physics Subcommittee of the Education Exhibits Committee

Richard Baron, MD
Chair, Education Exhibits Committee

Paul Chang, MD
Informatics Architect, RADScope
Member, Education Exhibits Committee
Member, Public Information Advisors Network
Member, Radiology Informatics Committee

Abraham Dachman, MD
Member, Committee to Review Exhibits in Computed Tomography for Radiographics
Member, Gastrointestinal Subcommittee of the Education Exhibit Committee
Member, Local Committee on Scientific Exhibits

Jia-Hong Gao, PhD
Chair, Session on Image Quality/Reproducibility, Annual Meeting

Aytekin Oto, MD
Member, Uroradiology Education Exhibits Committee

Xiaochuan Pan, PhD
Member, Physics Subcommittee of Scientific Program Committee for the Annual Meeting
Session Chair, Annual Meeting

David Paushter, MD
Member, Quality Round Table

Kenji Suzuki, PhD
Session Chair, Annual Meeting

Society for Imaging Informatics in Medicine
Paul Chang, MD
Member, Annual Program Committee
Member, Board of the College of SIIM Fellows
Section Leader, SIIM University

Society of Directors of Academic Medical Physics Programs
Samuel Armato, PhD
Member, Steering Committee

Society of Gastrointestinal Radiologists
Richard Baron, MD
President

Society of Interventional Radiology
Brian Funaki, MD
Course Director, Fellow’s Symposium

Society of Nuclear Medicine
Daniel Appelbaum, MD
Member, Committee on Education

BrainMap DataBase Journal
Jia-Hong Gao, PhD
Editorial Board

Computerized Tomography Theory and Applications
Xiaochuan Pan, PhD
Advisory Board

Editorial Board Memberships
Manuscript Reviewers

Academic Radiology
Samuel Armato, PhD
Charles Metz, PhD
Kenji Suzuki, PhD

American Board of Radiology
Daniel Appelbaum, MD (Self Assessment Modules in Nuclear Medicine)

American Journal of Perinatology
Aytekin Oto, MD

American Journal of Roentgenology
Abraham Dachman, MD
Kate Feinstein, MD
Jonathan Lorenz, MD
Aytekin Oto, MD
David Paushter, MD
Thuong Van Ha, MD

Bioinformatics and Biology Insights
Kenji Suzuki, PhD

Cancer
Thuong Van Ha, MD

Cardiovascular and Interventional Radiology
Jonathan Lorenz, MD
Cerebral Cortex
Jia-Hong Gao, PhD

Clinical Medicine: Case Reports
Kenji Suzuki, PhD

Computer Vision and Image Understanding
Kenji Suzuki, PhD

Computerized Medical Imaging and Graphics
Kenji Suzuki, PhD

Diagnostic and Interventional Radiology
Aytekin Oto, MD

European Radiology
Aytekin Oto, MD

IEEE Nuclear Science Symposium and Medical Imaging Conference Abstracts
Bill O’Brien-Penney, PhD

IEEE Transactions on Biomedical Engineering
Kenji Suzuki, PhD

IEEE Transactions on Image Processing
Kenji Suzuki, PhD

IEEE Transactions on Information Technology in Biomedicine
Kenji Suzuki, PhD

IEEE Transactions on Medical Imaging
Samuel Armato, PhD
Chien-Min Kao, PhD
Patrick La Rivière, PhD
Xiaochuan Pan, PhD
Kenji Suzuki, PhD

IEEE Transactions on Neural Networks
Kenji Suzuki, PhD

IEEE Transactions on Nuclear Science
Chien-Min Kao, PhD
Patrick La Rivière, PhD

Human Brain Mapping
Jia-Hong Gao, PhD

International Conference on Pattern Recognition
Kenji Suzuki, PhD

International Conference on Smart Homes and Health Telematics
Kenji Suzuki, PhD

International Journal of Computer-Assisted Radiology and Surgery
Kenji Suzuki, PhD

Journal of Biomedical Informatics
Charles Metz, PhD

Journal of Computer Assisted Tomography
Abraham Dachman, MD
Aytekin Oto, MD

Journal of Magnetic Resonance
Jia-Hong Gao, PhD

Journal of Magnetic Resonance Imaging
Jia-Hong Gao, PhD

Journal of Nuclear Medicine
Daniel Appelbaum, MD
Patrick La Rivière, PhD
Yonglin Pu, MD

Journal of the American Medical Association
Jonathan Lorenz, MD

Journal of Vascular and Interventional Radiology
Brian Funaki, MD
Jonathan Lorenz, MD

Journal of Visual Communication and Image Representation
Kenji Suzuki, PhD

Leukemia and Lymphoma
Daniel Appelbaum, MD

Liver Transplantation
Brian Funaki, MD
Jonathan Lorenz, MD
Aytekin Oto, MD
Yonglin Pu, MD
Thuong Van Ha, MD

Magnetic Resonance Imaging
Jia-Hong Gao, PhD

Magnetic Resonance in Medicine
Jia-Hong Gao, PhD

Medical Engineering & Physics
Kenji Suzuki, PhD

Medical Physics
Samuel Armato, PhD
Chien-Min Kao, PhD
Patrick La Rivière, PhD
Robert Nishikawa, PhD
Xiaochuan Pan, PhD
Kenji Suzuki, PhD

Neuroanatomy
Aytekin Oto, MD
Scientific Presentations

American Association of Physicists in Medicine
Minneapolis MN, July 22–26, 2007

Armato SG III, Pearson EA, Roberts RY, Sensakovic WF, Caligiuri P: Assessment of Mesothelioma Tumor Response: Correlation of Tumor Thickness and Tumor Area.

IEEE International Symposium on Biomedical Imaging
Paris France, May 14-17, 2008


Institute of Electrical and Electronics Engineers Nuclear Science Symposium and Medical Imaging Conference, Honolulu Hawaii, October 27–November 3, 2007


Kao CM: Windowed Image Reconstruction for TOF-PET.


Kao CM, Xie Q, Dong Y, Han X, and Chen CT: Performance Characterization of a High-sensitivity Small-animal PET Scanner.

Xie Q, Kao CM, Dong Y, Han X, and Chen CT: Potential Advantages of Digitally Sampling Scintillation Pulses in Timing Determination in PET.


International Symposium on Virtual Colonoscopy Boston MA, October 15-17, 2007


Lostumbo A, Tsai J, Suzuki K, Dachman AH: Comparison of 2D and 3D Views for Measurement and Conspicuity of Flat Lesions in CT Colonography.

Suzuki K, Sheu I, Epstein ML, Verceles J, Rockey DC, Dachman AH: Performance of CAD Based on MTANNs for Detection of False-negative Polyps in a Multicenter Clinical Trial.


Ichikawa K, Hasegawa M, Abe H, Shiraishi J, Doi K: Development of Super-high Resolution LCDs with 16 and 9 Mega-pixels for Displaying High-resolution Radiological Images.


Jansen SA, Yang C, Abe H, Shimauchi A, Karczmar G, Newstead GM: DCEMRI of Malignant Breast Lesions: Should a Fixed Volume of Contrast be Injected, or a Fixed Dose?


Pu Y, Huang Y, Li Q, Chen C, Appelbaum DE: Inter-observer Variability between Measurements of the Maximal Standardized Uptake Value on FDG PET/CT and Measurements of the Tumor Size on Diagnostic CT in Patients with Lymphoma.


Suzuki K, Verceles J, Khankari S, Rockey DC, Dachman AH: Performance of a CAD Scheme Incorporating a Massive Training Artificial Neural Network (MTANN) for Detection of Polyps in False-Negative CT
Colonography Cases in a Large Multicenter Clinical Trial.


San Antonio Breast Cancer Symposium
San Antonio TX, December 13-16, 2007


Jansen SA, Abe H, Shimauchi A, Karczmar GS, Newstead GM: How Does ER/PR and Her2/Neu Status affect the MR Characteristics of Invasive Ductal Carcinoma?


Society for Imaging Informatics in Medicine Annual Meeting
Providence RI, June 2007


Society for Magnetic Resonance Imaging in Medicine
Toronto Ontario, May 3-9, 2008


Jansen SA, Karczmar G, Shimauchi A, Abe H, Newstead GM: Are Kinetic Parameters Related to Prognostic Indicators in <2.0 cm Invasive Ductal Carcinomas?

Jansen SA, Newstead GM, Conzen SD, Zamora M, Krausz T, Karczmar G: Do All in situ Cancers Progress to Invasive Disease? A First Look at Progression of Mammary Cancer from in situ to Invasive Carcinoma in vivo.


Society of Skeletal Radiology Meeting
La Quinta CA, March 2008

Stacy GS: Sarcoma Arising in Osteonecrosis.

SPIE Medical Imaging 2008
San Diego CA, Feb 16-21, 2008

Kao CM, Dong Y, Xie Q: Noise Evaluation of Accurate Image Reconstructions for a Dual-head Small-animal PET.


Wan L, Wu Z, Zhou F, Ye S, Zeng S, Kao CM, Chen CT, Zhang Y, and Xie Q: The Effects of Respiration Motion in PET/CT Studies.
Symposium on Radiation Measurements and Applications
Berkeley CA, June 2-5, 2008


Invited Presentations

Daniel Appelbaum, MD

Bone Scintigraphy Review. Society of Nuclear Medicine, Nuclear Medicine Board Review course, New Orleans LA, June 14, 2008.

Identifying Unknown Whole Body Scans. Chicago Radiological Society meeting, Rush Presbyterian Medical Center, Chicago IL, April 17, 2008.


PET/CT Imaging: Overview and Update. Grand Rounds, St. Mary’s Medical Center, Knoxville TN, February 7, 2008.

Paul Chang, MD


Leveraging Informatics to Enhance Radiology Relevance and Value. President’s Address and Opening Session, Radiological Society of North America, Chicago IL, December 2007.

Re-engineering Radiology in an Electronic World: Radiologist as Value Innovator. Illinois Radiology Society, Chicago IL, March 15, 2008. Also presented in Grand Rounds, Indiana University School of Medicine, Methodist Hospital, Indianapolis IN, April 21, 2008.

Abraham Dachman, MD

Director, Free Paper Sessions; and Panelist: Plenary Session #6: Practical Issues for Dissemination.


Faculty, Course on CT Colonography, Supervised Case Review. American College of Radiology, Reston VA, March 16-18, 2008.


Faculty, Hands-on CTC Course; and Workshop, joint with P. Lefere: Virtual Colonoscopy Pitfalls of Interpretation. Society of Gastrointestinal Radiologists, Palm Desert CA, February 17-22, 2008.

Kate Feinstein, MD


Brian Funaki, MD


Enteral Feeding. Society of Interventional Radiology Fellow’s Spring Symposium, May 9, 2008.


Vascular Physiology and Anatomic Variants. True Confessions: What I Wish I Hadn’t Done. Metallic Stent

Jia-Hong Gao, PhD


Patrick La Rivière, PhD

Development of Protease-sensitive Molecular Probes and Acoustic Attenuation Correction Schemes for Optoacoustic Tomography. National Taiwan University, Taipei, Taiwan, 2007.


Penalized-likelihood Sinogram Preprocessing for Low-dose and Non-contrast Computed Tomography. Department of Biomedical Engineering, Purdue University, 2008.

Sinogram Preprocessing for Low-dose Computed Tomography. Chang Gung Memorial Hospital, Taiwan, 2007.

Jonathan Lorenz, MD


Heber MacMahon, MD


Robert Nishikawa, PhD


Computer-Aided Diagnosis: Get Ready, It’s Coming to a Workstation near You! Practical Course in Medical Digital Imaging & Teleradiology, Toronto Canada, March 2008.

Aytekin Oto, MD


New Developments in Small Bowel Imaging and Board Drills. Visiting professor at University of Texas Medical Branch at Galveston TX, April 7, 2008.


Sidney Regalado, MD

Vascular and Interventional Radiology Unknown Cases. Chicago Radiological Society Resident and Fellow Section, Chicago IL, April 17, 2008.

Kenji Suzuki, PhD

Computer-aided Diagnosis Research at the University of Chicago. School of Life System Science and Technology, Chukyo University, Aichi Japan, 2007.

Machine Learning for Computer-aided Diagnosis. UCSD Radiation Oncology Academic Seminar Series, Department of Radiation Oncology, the Moores Cancer Center, the University of California at San Diego, 2008.

Massive-training Artificial Neural Networks (MTANNs) for Computer-aided Diagnosis in Digital X-rays. JPI, Seoul South Korea, 2008.

Recent Progress in Computer-aided Diagnosis (CAD) Research of the Chest and Abdomen at the University of Chicago. Graduate School of Engineering, University of Tokushima, Tokushima Japan, 2008.

Recent Progress in Development of Computer-aided Diagnosis (CAD) at the University of Chicago: Massive-training Artificial Neural Networks (MTANNs). Konica Minolta Medical & Graphic, Tokyo Japan, 2008.

Recent Progress in Computer-aided Diagnosis Research at the Kenji Suzuki Lab at the University of Chicago. Seminar, Faculty of Information Science and Technology, Aichi Prefectural University, Aichi Japan, 2008.

Thuong Van Ha, MD


Michael Vannier, MD

Neuroimaging Visualization and Analysis. Royal Dental College, Copenhagen DK, April 2008.

Neuroimaging Workshop. Mathematical Biosciences Institute, Ohio State University, Columbus OH, June 2008.

President’s Symposium on Imaging Biomarkers. American Association of Physicists in Medicine, July 2007.

David Yousefzadeh, MD
Application of US and Doppler in Pediatric MSK Disorders with Major Emphasis on Infectious Disorders. Society for Pediatric Radiology, Scottsdale AZ, May 6-10, 2008.

Steve Zagan, MD


Mario Zaritzky, MD


Nishikawa RM, Pesce L: Physics Case of the Day.


Reiser I, Nishikawa RM, Seifi P: Image Quality and Artifact Conspicuity in Breast Tomosynthesis.


Lau BA, Reiser I, Nishikawa RM: Microcalcification Detectability in Tomosynthesis. (Awarded Cum Laude Poster Award).


Peer-Reviewed Publications


La Rivière PJ and Vargas PA: Correction for Resolution Non-uniformities Caused by Anode Angulation in Computed Tomography. *IEEE Transactions on Medical Imaging* (accepted for publication).


Invited Publications


Molvar C, Funaki B: Hypothenar Hammer Syndrome. *AJR Integrative Imaging* (Accepted for publication).


**Abstracts & Proceedings**


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**Grants & Contracts**

*ACTIVE JULY 1, 2007- JUNE 30, 2008*

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**Primary Investigators**

**Samuel Armato, PhD**

**Title:** Computerized Analysis of Mesothelioma on CT Scans

**Agency:** National Cancer Institute

**Project Period:** 6/1/2006-5/31/2010

**DC/IDC/Total:** $943,978/$488,019/$1,431,997

**Title:** Medical Informatics Experiences in Undergraduate Research

**Agency:** National Science Foundation

**Project Period:** 2/1/2008-1/31/2011

**DC/IDC/Total:** $59,404/$6,182/$65,586

**Title:** Standard Database for CT Lung Images

**Agency:** National Cancer Institute

**Project Period:** 8/20/2001-7/31/2007

**DC/IDC/Total:** $1,079,391/$532,950/$1,612,341

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**Chin-Tu Chen, PhD**

**Title:** AFIP-UC Collaborative Research Agreement

**Agency:** AFIP

**Project Period:** 5/2/2007-5/1/2009

**DC/IDC/Total:** $335,000/$0/$335,000

**Title:** Biomedical Imaging Research

**Agency:** National Health Research Institute

**Project Period:** 3/1/2007-2/28/2009

**DC/IDC/Total:** $153,500/$12,280/$165,780

**Title:** Hybrid Microspect/MicroCT for Quantitative Imaging

**Agency:** National Institutes of Health

**Project Period:** 3/1/2008-2/28/2009

**DC/IDC/Total:** $500,000/$0/$500,000
Abraham Dachman, MD  
Title: Comparison of Linear Dimensions and Polyp Volumes in CTC  
Agency: Philips Medical System  
DC/IDC/Total: $10,225/$4,090/$14,315

Title: National CT Colonography Trial  
Agency: National Cancer Institute  
DC/IDC/Total: $104,918/$55,082/$160,000

Kunio Doi, PhD  
Title: CAD for CT Nodules in Lung Cancer Detection  
Agency: National Cancer Institute  
Project Period: 9/19/2003-8/31/2008  
DC/IDC/Total: $884,771/$446,668/$1,331,439

Title: Evaluation & Analysis of CAD Scheme for Detection of Nodules  
Agency: Riverain  
DC/IDC/Total: $120,000/$48,000/$168,000

Title: Psychophysical Measures for Selection of Similar Images  
Agency: Department of Defense/Army Research Office  
Project Period: 3/15/2005-4/14/2008  
DC/IDC/Total: $83,777/$6,223/$90,000

Maryellen Giger, PhD  
Title: Computerized Radiographic Analysis of Bone Structure  
Agency: National Institute of Arthritis and Musculoskeletal and Skin Diseases  
DC/IDC/Total: $849,025/$454,229/$1,303,254

Title: Correlative Feature Analysis for Multimodality Breast CAD  
Agency: Department of Defense/Army Research Office  
DC/IDC/Total: $90,000/$7,200/$97,200

Title: Optimization of CAD Output in Breast Imaging  
Agency: National Cancer Institute  
DC/IDC/Total: $1,022,636/$544,553/$1,567,189

Title: Research Training in Medical Physics  
Agency: National Institute of Biomedical Imaging & Bioengineering  
Project Period: 5/1/2005-4/30/2010  
DC/IDC/Total: $1,536,221/$95,913/$1,632,134

Maryellen Giger, PhD  
Title: Support MRI of Current Density and Current Pathways Study  
Agency: Department of Defense/Office of Navy Research  
DC/IDC/Total: $14,930/$7,987/$22,917

Title: Computer-Aided Analysis of Histopathology Images of Prostate  
Agency: National Institute of Biomedical Imaging & Bioengineering  
DC/IDC/Total: $312,892/$117,214/$430,106

Title: Computer-Aided Diagnosis of Breast Lesions in Mammograms  
Agency: National Cancer Institute  
Project Period: 4/1/2002-6/30/2009  
DC/IDC/Total: $986,616/$527,839/$1,514,455

Chien-Min Kao, PhD  
Title: Development and Evaluation of an IGRT Technology for Prostate Cancer  
Agency: American Cancer Society  
Project Period: 1/1/2002-12/31/2005  
DC/IDC/Total: $20,000/$0/$20,000
Gregory Karczmar, PhD  
**Title:** Detection & Evaluation of Early Breast Cancer via MRI  
**Agency:** Department of Defense / Army Research Office  
**Project Period:** 2/6/2006-3/5/2009  
**DC/IDC/Total:** $83,333/$6,667/$90,000  

**Title:** Dynamic Spatial and Spectral Contrast Enhanced MRI of Breast  
**Agency:** National Cancer Institute  
**Project Period:** 7/1/2005-6/30/2008  
**DC/IDC/Total:** $254,969/$135,118/$390,087  

**Title:** Fast Spectroscopic MR Imaging of Breast Cancer  
**Agency:** National Institute of Biomedical Imaging & Bioengineering  
**Project Period:** 9/1/1999-2/28/2009  
**DC/IDC/Total:** $652,478/$342,550/$995,028  

**Title:** High Spectral/Spatial Resolution Imaging Breast Cancer  
**Agency:** National Institute of Biomedical Imaging & Bioengineering  
**Project Period:** 9/15/2003-7/31/2008  
**DC/IDC/Total:** $805,241/$422,753/$1,227,994  

**Title:** Implementation of Improved Spectral, Temporal & Spatial Sampling Methods  
**Agency:** Philips Medical System  
**Project Period:** 4/1/2006-3/31/2008  
**DC/IDC/Total:** $144,862/$57,945/$202,807  

**Title:** Microvessel Density with High Spectral/Spatial MRI  
**Agency:** National Cancer Institute  
**Project Period:** 9/20/2007-8/31/2010  
**DC/IDC/Total:** $877,942/$441,203/$1,319,145  

**Title:** SPORE in Breast Cancer  
**Agency:** National Cancer Institute  
**Project Period:** 9/27/2006-7/31/2011  
**Total:** $1,522,490  

**Title:** Penalized Livelihood Sinogram Smoothing & Restoration  
**Agency:** Schweppes  
**Project Period:** 4/1/2005-3/31/2008  
**DC/IDC/Total:** $100,000/$0/$100,000  

**Title:** System Design, Algorithm Development and Verification  
**Agency:** Department of Defense / Army Research Office  
**Project Period:** 5/1/2008-5/31/2011  
**DC/IDC/Total:** $90,000/$7,200/$97,200  

Charles Metz, PhD  
**Title:** Improved DBM ROC Methods for Diagnostic Radiology  
**Agency:** National Institute of Biomedical Imaging & Bioengineering  
**Project Period:** 4/1/2007-3/31/2008  
**DC/IDC/Total:** $279,919/$149,757/$429,676  

**Title:** Receiver Operating Characteristic (Roc) Analysis  
**Agency:** National Institute of Diabetes and Digestive and Kidney Diseases  
**Project Period:** 9/29/2007-9/28/2008  
**DC/IDC/Total:** $232,979/$124,645/$357,624  

Gillian Newstead, MD  
**Title:** Computer-Aided Diagnosis (CADx) Systems for Breast MR  
**Agency:** Philips Medical System  
**Project Period:** 6/1/2006-5/31/2009  
**DC/IDC/Total:** $93,000/$37,200/$130,200  

**Title:** New Approaches to Sampling & Analyzing Contrast Media  
**Agency:** National Cancer Institute  
**Project Period:** 7/8/2005-6/30/2008  
**DC/IDC/Total:** $233,469/$123,831/$357,300  

Robert Nishikawa, PhD  
**Title:** A Novel Method for Determining Image Similarity  
**Agency:** National Institute of Biomedical Imaging & Bioengineering  
**Project Period:** 9/1/2005-8/31/2007  
**DC/IDC/Total:** $100,382/$52,701/$153,083  

**Title:** Advanced High-Resolution Two-Dimensional X-Ray Detector  
**Agency:** National Institute of Biomedical Imaging & Bioengineering  
**Project Period:** 2/1/2008-11/30/2008  
**DC/IDC/Total:** $44,081/$23,583/$67,664  

Patrick La Rivièrè, PhD  
**Title:** Molecular Probes & System Development for Optoacoustic Imaging of Proteases in Breast Cancer  
**Agency:** National Cancer Institute  
**Project Period:** 9/27/2006-7/31/2011  
**DC/IDC/Total:** $25,000/$13,375/$38,375  

**Title:** Molecular Probes & Techniques for Optoacoustic Imaging  
**Agency:** American Cancer Society  
**Project Period:** 7/1/2008-6/30/2012  
**DC/IDC/Total:** $90,000/$7,200/$97,200
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<tr>
<th>Title</th>
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<th>DC/IDC/Total</th>
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<td>Comparison of Computer-Aided Detection on Digital &amp; Film</td>
<td>Illinois Department of Public Health</td>
<td>7/1/2007-6/30/2008</td>
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<td>Optimization of Breast Tomosynthesis Imaging Systems</td>
<td>Department of Defense/Army Research Office</td>
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<td>Mammography Computer Aided Detection (CAD)</td>
<td>Kodak</td>
<td>8/1/2006-7/31/2007</td>
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<td>Development of Innovative MRI Methods To Improve Early Breast Cancer Detection</td>
<td>Illinois Department of Public Health</td>
<td>1/1/2008-6/30/2009</td>
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<td>Optimized Cone-Beam CT for Image-Guided Radiation Therapy</td>
<td>National Cancer Institute</td>
<td>7/27/2007-5/31/2012</td>
<td>$1,250,000/$617,390/$1,867,390</td>
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<td>Phase-Enhancement Micro-Computed Tomography</td>
<td>Department of Energy</td>
<td>10/1/2006-9/30/2008</td>
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<td>Targeted Imaging in Helical Cone Beam CT</td>
<td>National Institute of Biomedical Imaging &amp; Bioengineering</td>
<td>7/1/2000-8/31/2008</td>
<td>$940,101/$456,508/$1,396,609</td>
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<td>Imaging Pancreatic B-Cell Function by Magnetic Resonance</td>
<td>National Institute of Biomedical Imaging &amp; Bioengineering</td>
<td>9/30/2003-7/31/2009</td>
<td>$981,170/$442,041/$1,423,211</td>
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<td>NMR Detection of Gene Expression</td>
<td>National Heart, Lung, &amp; Blood Institute</td>
<td>8/1/2003-7/31/2009</td>
<td>$765,440/$323,537/$1,088,977</td>
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<td>Helical CT Reconstruction and Lung Cancer Screening</td>
<td>National Institute of Biomedical Imaging &amp; Bioengineering</td>
<td>8/1/2004-7/31/2008</td>
<td>$311,803/$24,944/$336,747</td>
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<td>3D Massive Training ANN for CAD for Colon Cancer in CT Colonography</td>
<td>National Cancer Institute</td>
<td>9/26/2007-7/31/2011</td>
<td>$760,000/$406,600/$1,166,600</td>
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<td>Advanced Computer-Aided Detection of Colon Cancer in CT Colonography</td>
<td>American Cancer Society - Illinois Division</td>
<td>4/1/2007-3/31/2009</td>
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Title: Analysis of Computer-Aided Detection of Lung Nodules in Chest Radiology
Agency: Riverain
Project Period: 10/1/2006-9/30/2008
DC/IDC/Total: $60,714/$24,286/$85,000

Title: Development of Advanced CAD System for Early Detection of Colorectal Cancer in CT Colonography
Agency: Cancer Research Foundation, Young Investigator Awards
DC/IDC/Total: $50,000/$0/$50,000

Title: Development & Evaluation of Computer-Aided Detection of Polyps in CT Colonography on False Negative Cases in Large Multicenter Clinical Trail
Agency: Radiological Society of North America Research & Education Fund
Project Period: 7/1/2006-6/30/2008
DC/IDC/Total: $30,000/$0/$30,000
The Annual Faculty Holiday Party,
December 8, 2007 at The Art Institute of Chicago.
The Staff Holiday Party, December 21, 2007 at Ida Noyes Hall.

Graduation Party for the Residents, June 7, 2008 at N9NE Steakhouse.
RICHARD L. BARON, MD
Chairman

DAVID M. PAUSHTER, MD
Executive Vice Chair, Clinical Operations

MARYELLEN L. GIGER, PHD
Vice Chair for Basic Science Research

MICHAEL VANNIER, MD
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Interim Executive Administrator
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DIANE BERNAHL, MHA, CPC
Assistant Director, Practice Operations & Faculty Affairs

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Assistant Director, Radiology Engineering

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Assistant Director, Finance

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Saad Naseer, MD
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Susan Sung, MD

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Danny Cheng, MD
Jack Collins, MD
Nicholas Krause, MD
Jay Patel, MD
Sarah Ronan, MD
William Whetsell, MD

(Second Year)
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Michael Hutchinson, MD
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Hao Lo, MD
Evan Nichols, MD
Michael Noud, MD
David Schacht, MD

(Third Year)
Samantha Fienberg, MD
Monica Harish, MD
Gregory Henkle, MD
Sheela Konda, MD
Albert Li, MD
Michael Lester, MD
Christopher Molvar, MD

(Fourth Year)
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Rodney Corby, MD
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Rajshri Shah, MD
Steven Thiel, MD
Carl Valentin, MD
Ivica Vucic, MD

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Darrin Edwards, PhD
Xiaobing Fan, PhD
Chad Haney PhD
Feng Li, PhD
Hui Li, PhD
Milica Medved, PhD
Ingrid Reiser, PhD
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Ming Chi Shih, PhD
Jeffrey Souris, PhD

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Michael Chinander, PhD
Lara Leoni, PhD
Guihua Zhai, PhD

Post Doctoral Fellows
Hee-Jong Kim, PhD
Ji Li, PhD

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Ryohei Nakayama, PhD
Katsutoshi Sugimoto, PhD

Emeritus
John Fennessy, MD
Martin Lipton, MD
Chien-Tai Lu, MD

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Jonathan Silverstein, MD
Kim Williams, MD

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Chin Tu Chen, PhD
Kunio Doi, PhD
Jia Hong Gao, PhD
Maryellen Giger, PhD
Yulei Jiang, PhD
Chien-Min Kao, PhD
Greg Karczmar, PhD
Patrick LaRiviere, PhD
Charles Metz, PhD
Robert Nishikawa, PhD
Bill O’Brien-Penney, PhD
Xiaochuan Pan, PhD
Brian Roman, PhD
Kenju Suzuki, PhD

Visiting Appointments
Ryohei Nakayama, PhD
Katsutoshi Sugimoto, PhD

Secondary Appointments
in Radiology
Jonathan Silverstein, MD
Kim Williams, MD