ASU-Mayo Clinic Imaging Informatics Laboratory (AMIIL)

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http://amiil.engineering.asu.edu/

Focus Area I:
Imaging-centered data analytics for better diagnosis and treatment of cancer and other diseases

Focus Area II:
Operational excellence, process and quality improvement, work flow efficiency

Focus Area III:
Clinical unitization (*focused diseases*: glioblastoma multiforme (GBM), hepatocellular carcinoma (HCC), prostate cancer, oropharyngeal squamous cell carcinoma (OPSCC), migraine, Alzheimer's disease; *imaging modalities*: CT, DECT, MRI, PET)

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Collaborators at Mayo Clinic

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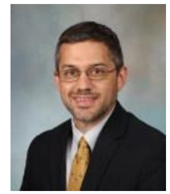
Neurology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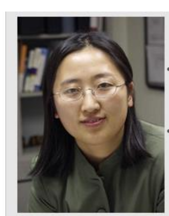
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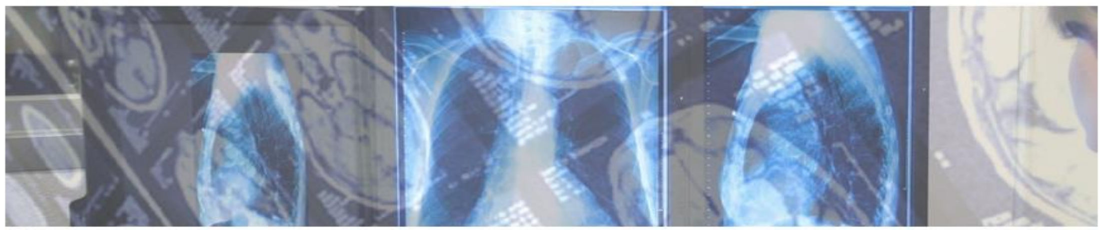

Mission Statement

The ASU-Mayo Clinic Imaging Informatics Laboratory (AMIIL) is a collaborative effort between the School of Computing, Informatics, and Decision Systems Engineering at ASU and the Department of Radiology at Mayo Clinic Arizona. Our goal is to improve patient care by analyzing and managing information in radiology images and databases. We achieve this goal by developing novel informatics, statistics & machine learning, and systems engineering approaches.

Thrust Areas

Thrust I: System Informatics and Process Improvement
- Operational efficiency, process optimization, lean six sigma

Thrust II: Basic Radiology Informatics & Analytics research
- Imaging processing and fusion
- Statistical modelling and machine learning

Thrust III: Clinical Applications and Proven Value
- Targeting important diseases: Brain Tumor, HCC, Fatty Liver
- Focusing on multi-fold clinical outcomes: diagnosis, treatment response, reoccurrence, survival, quality of life
- Utilizing multi-source information: multi-modality imaging, genomics, lab tests, biopsy, demographics
- Involving multi-disciplinary medical experts: radiologists, oncologists, hepatologists

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Projects

Imagenomics

Personalized cancer medicine must consider regional genomic diversity of the tumor, because different regions of the same tumor, or th primary and metastatic tumors, can have widely variable genetic signatures. This diversity contributes to poor clinical outcomes such as treatment resistance and reoccurrence. To characterize global tumor genomics, the existing biopsy-based genetic profiling falls short be it is invasive, costly, time-consuming, and not part of standard clinical care. Therefore the genetic profiling can only be done for a few loc within a tumor. On the other hand, imaging techniques, such as CT, MRI, and PET, can non-invasively and fast scan the entire tumor in clinical care. Also, new evidence supports the hypothesis that imaging may reflect the underlying tumor genotypes. Imagenomics is of clinical interest because it could allow imaging to quickly and noninvasively determine global tumor genomics and, as a result, bring abo effective treatment that is optimized for regional genomic diversity. In this project, this goal will be achieved by novel machine learning approaches and solid clinical validation.

DICOM Index Tracker

The national press has highlighted concerns regarding the use of medical radiation. Methods are needed to assure that diagnostic medi radiation is properly prescribed and patients' radiation exposure is monitored. Accessing dosage amounts from medical records used to performed manually, causing difficulty in collecting information from digital imaging procedures into a central repository. The need to trac dosages has grown because of efforts within the medical community to lower radiation doses administered to patients. The DICOM (Di Imaging and Communications in Medicine) Index Tracker (DIT) is a system that keeps track of radiation doses. It monitors DICOM tags CT, nuclear imaging equipment, and other DICOM devices. The DIT records radiation activity, while providing automatic alerts to medica professionals if radiation exceeds a certain threshold. Web interface reporting is provided for accessing the database in real-time.

Dual Energy CT in Renal Stone Characterization

Characterizing renal stone composition has become an important issue for doctors in prescribing proper therapy renal stones require different treatments. Conventional MultiDetector CT is the most commonly used technique f but it has not been found to be very accurate for stone characterization. Recent studies utilizing a dual energy C shown promise in differentiating uric acid from non-uric acid stones in vitro. However, there are still problems witl classifications of non-uric acid stones, especially in vivo. The goal of this study is to evaluate the ability of DE-C different types of renal stones.

Model Based Iterative Reconstructing for CT dose reduction

Model Based Iterative Reconstructing (MBIR) focuses on reducing the dose of CT applied to hospital patients. Th involved in the CT dose reduction: (1) dose reduction following endovascular aneurysm repair (EVAR), (2) dose re (3) dose reduction and image enhancement of renal stone CT, and (4) dose reduction and image enhancement o

ResMD Mobile Image Viewer

Medical image viewing on mobile devices has become an important tool in diagnosing patient data effectively and efficiently. The traditionally used medical image viewing system, QREADS, does not provide the option of viewing medical images on mobile devices. A new mobile medical image viewing software, Resolution MD (ResMD) Mobile, is an advanced medical viewing product that allows access to radiology diagnostic images and reports from mobile devices (e.g., iPhone, iPad, etc.). It integrates all the tools necessary to make a diagnosis, including 2D images, MIP/MPR, 3D images, and interactive collaboration between physicians and radiologists. This project aims to determine if ResMD is better than QREADS in diagnostic quality, access time to images, technical reliability, and clinician satisfaction.

YesBoard

A common practice in radiology is to rely on employee initiatives to schedule and track imaging events. This situation not only causes process inefficiencies but also increases patient wait time and decreases service quality. In order to optimize the process and improve the care quality, a novel system that automatically organizes and publishes the information in real time is needed. The YesBoard project allows physicians and allied health staff to monitor radiology CT and MRI machines together with patient data and workflow in real time through any device with an internet connection and a browser. It will help to monitor CT and MRI patient data including high risk factors for intravenous contrast, wait times, equipment availability and workflow using a consolidated graphical presentation. This information will be collected then analyzed in order to streamline the process and optimize staff and machine scheduling. This project is expected to significantly improve the situational awareness of the current radiology care, improve process efficiency, optimize machine utilization and reduce costs, and provide good quality of care to patients.

MR Elastography

A common procedure for diagnosing hepatocellular carcinoma (HCC) is biopsy, a procedure that can result in mortality and misdiagnosis from sampling errors. Imaging techniques, such as ultrasonography, CT, and MRI, have been used. However, there are a large number of false positives from using these techniques. MR Elastography (MRE) is a novel, multi-parametric image enhancing technique that can be used to assess the mechanical properties of human tissues. MRE adds image signatures derived from MR intensity that can be effective in evaluating external structural determinants. The objective of this study is to show that MRE can accurately (1) determine the risk of developing HCC, (2) discriminate HCC from nonmalignant cirrhotic nodules, (3) assess response to therapy at timepoints earlier than conventional imaging techniques, and (4) predict the risk of HCC recurrence.

Dual Energy CT in Fatty Liver

Steatosis in the liver can most accurately be imaged with MRI. Though clinicians usually prefer MRI over CT (because of radiation concerns), MRI has not been found to quantify fibrosis. Dual Energy CT (DE-CT) is a new imaging technique that can create images to identify quantitative tissue differences in x-ray images. It is more sensitive to small density differences than conventional CT, and is a potentially cost-effective alternative to MRI. The objective of this project is to develop an optimized DE-CT imaging pipeline. The goal of this imaging pipeline is to achieve a low dose acquisition protocol design and develop imaging informatics, which may revolutionize fatty liver disease diagnosis.

Texture Analysis

Texture characterization is an important problem in medical image analysis. As biological tissues become abnormal during the progression of a disease, their underlying texture may also change. Current magnetic resonance (MR) images of tissues are not capable of providing microscopic information that can be assessed visually. However, histological alterations that are present in some illnesses may bring about texture changes in the MR image that are amenable to quantification through texture analysis. This study will concentrate on texture analysis (TA) of hepatocellular carcinoma (HCC). A comparative experiment will be performed between two different TA methodologies: (1) "Haralick's Co-occurence Matrix", the traditional method, and (2) "FTFT-RIST", a new TA methodology based on S transform. The goal is to determine which TA methodology is faster and more accurate.

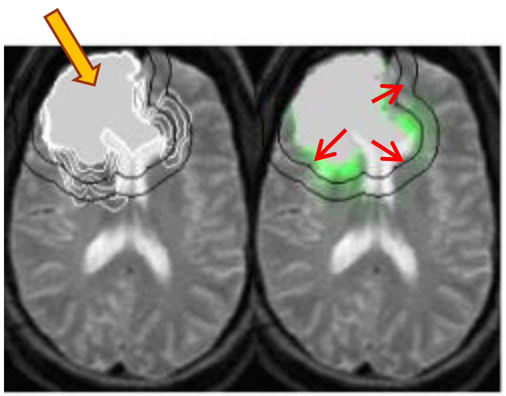
Project Example I: Imagenomics for Characterizing Invading Cancer Cell Genomic Diversity

- Collaborative research between ASU, Mayo Clinic Arizona, and Translational Genomics Research Institute

Clinical question:
Cancer cell invasion to surrounding normal issues greatly contributes to treatment failure

Glioblastoma multiforme (GBM) tumor

Tumor cell invasion



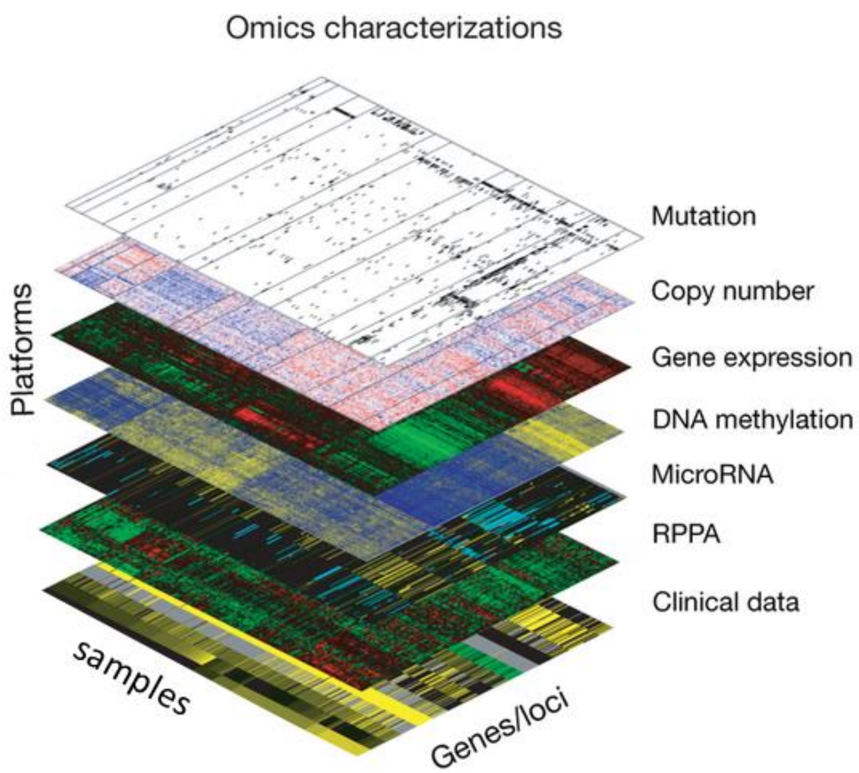
Project Example I: Imagenomics for Characterizing Invading Cancer Cell Genomic Diversity

State of the art:

- Gene expression data focused
- Identify differentially expressed genes between tumor cells and invading cells

What is needed:

- Multi-platform genomic data integration
- Understand genetic basis of invasive behavior
- New biomarkers correlated with invasive severity and treatment response
- Novel combination therapies to address both tumor core and invading area

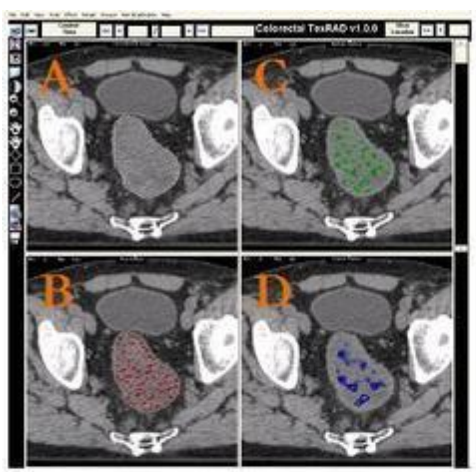


Project goal I:
Multi-platform integrative genomic data analysis for invasion biomarker identification

Project Example I: Imagenomics for Characterizing Invading Cancer Cell Genomic Diversity

A further clinical question:
Can imaging inform genomic diversity without biopsy?

- Our group has found imaging texture features correlated with expression, promoter methylation, and copy number aberration of hallmark genes for a few cancers.
- Imaging texture analysis extracts spatial information from image pixels at fine-to-coarse scales and quantifies tumor heterogeneity that cannot be seen by naked eyes.



A: tumor image
B-D: texture analysis reveals texture features at different scales that cannot be seen by naked eyes

Project goal II:
Correlating imaging texture features and genomic diversity and identifying imaging surrogate markers

Project Example II: Health Informatics for Efficient and Quality-Assured Health Care Operation

A big hurdle to health care operation:
Information is stored in disparate data sources and in non-standardized formats, hindering many operational questions from being addressed.

- Is it OK to schedule a CT scan for my patient in two weeks without radiation overdose?
- Which scanner will be available at the time my patient arrives so he won't have to wait?
- Are there too many adverse safety events this month in my department, what are they, and what are the root causes?

Where is the information?

How to analyze it?

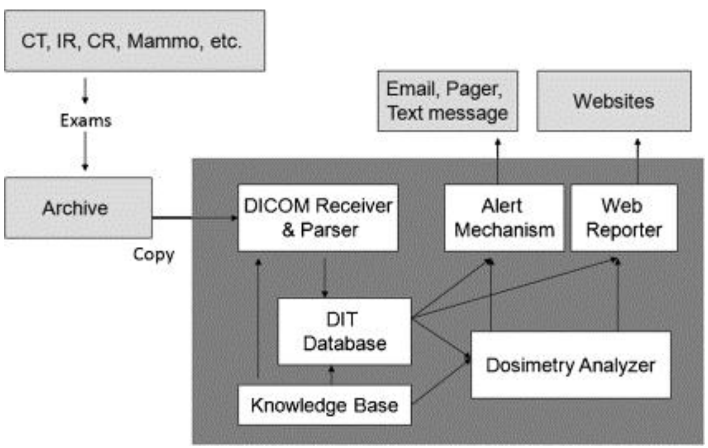
How to present it?

Project Example II: Health Informatics for Efficient and Quality-Assured Health Care Operation

Our Objective:
Track, standardize, correlate information in disparate data sources, analyze the information, and present the result in user-friendly formats

Example Project – Radiation Dose Index Tracker

- Track cumulative radiation dose amount from multi-time, multi-imaging, multi-scanner medical records
- Real-time query and alarming



Software system architecture

Real-time query/reporting

Real-time alarming

Thank you !