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UC HEALTH RADIOLOGY

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The Newsletter of the UC Health Departments of Radiology, Biomedical Imaging, and Radiological Sciences

Continuing the Digital Legacy

Application of AI in Radiology

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Welcome from the Chairs

Welcome to the inaugural issue of *UC Health Radiology* — The Newsletter of the UC Health Departments Radiology, Biomedical Imaging, and Radiological Sciences. As chairs representing our five University of California campuses (UC Davis, UCLA, UC Irvine, UCSD, and UCSF), we are honored to introduce you to this new publication that highlights how we are shaping the future of radiological sciences and biomedical imaging across California.

Within the University of California system, the historical relationships built among our UC radiology departments (Davis, Irvine, UCLA, UCSD, and UCSF) have enabled continuous innovation in research and clinical care. It has been with the support and collaboration of each radiology department that the UC system has been at the forefront of noninvasive and evidence-based treatments. This relationship has fostered efforts such as the Appropriate Imaging Coalition (AIC), which develops evidence-based criteria for medical imaging at each of the five schools, and UC's certification as a qualified provider-led entity (QPLE).

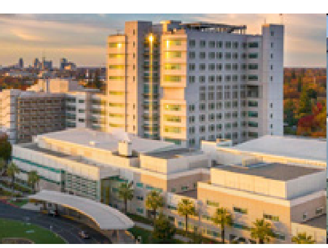
Our goal together as the five University of California departments is to continue to bring the latest advances in imaging research, radiological sciences education and patient care services to leverage our collaborative strength throughout the state. Our depth and breadth of services, with our world-class faculty offer unparalleled opportunities in terms of size, scale and reach. UC Davis, UC Irvine, UCLA, UC San Diego and UCSF, will continue to combine our globally recognized knowledge and experience to improve clinical practice, reduce patient costs, and dramatically increase operational efficiencies.

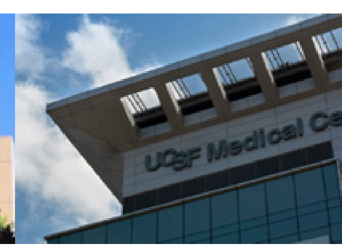
The field of radiology has always been on the forefront of digital innovation. For example, the first conversion of radiograph images to an electronic format (PACS) occurred over 30 years ago. Our five departments are continuing this digital legacy in the application of AI (artificial intelligence) and machine learning — the theme for this inaugural newsletter issue. Here you will find the innovative work of AI in the clinical setting, for example its use in device placement in chest x-rays and in the development of new 3D imaging tools for the first total-body positron emission tomography. As well, you will read of the establishment of cross-disciplinary centers such at the CAIDM (Center for Artificial Intelligence in Diagnostic Medicine) and ci2 (Center for Intelligent Imaging), where faculty, scientists and educators collaborate across the fields of data science, medicine and engineering to pioneer the next digital transformations within our field.

The work of our faculty within AI and machine learning is truly just beginning and we are excited to share a few of the recent highlights and accomplishments across our departments. You will also find information on our second annual UC Artificial Intelligence in Radiology conference for 2020 *(see back page)*. Last year's event was by all measures a success attracting participants across the UC sites and highlighted the strong cross-campus collaboration and enthusiasm for AI in radiology. Perhaps we will see you there this fall!

Sincerely,
Ray Dougherty
Dieter Enzmann
Christopher Hess
Alexander Norbash
Vahid Yaghmai

“The field of radiology has always been on the forefront of digital innovation. Our five departments are continuing this digital legacy in the application of AI (artificial intelligence) and machine learning .”



UCSF

AI Can Detect Alzheimer's Disease in Brain Scans Six Years Before a Diagnosis

Using a common type of brain scan, researchers programmed a machine-learning algorithm to diagnose early-stage Alzheimer's disease about six years before a clinical diagnosis is made — potentially giving doctors a chance to intervene with treatment.

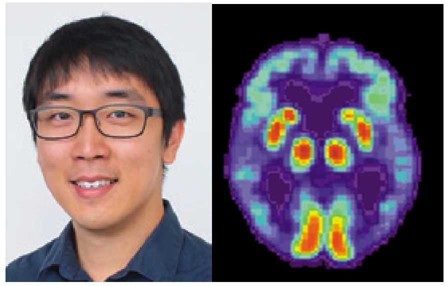
No cure exists for Alzheimer's disease, but promising drugs have emerged in recent years that can help stem the condition's progression. However, these treatments must be administered early in the course of the disease in order to do any good. This race against the clock has inspired scientists to search for ways to diagnose the condition earlier.

"One of the difficulties with Alzheimer's disease is that by the time all the clinical symptoms manifest and we can make a definitive diagnosis, too many neurons have died, making it essentially irreversible," says Jae Ho Sohn, MD, MS, a resident in the Department of Radiology and Biomedical Imaging at UC San Francisco.

Prediction model

In a recent study, published in *Radiology*, Sohn combined neuro-imaging with machine learning to try to predict whether or not a patient would develop Alzheimer's disease when they first presented with a memory impairment — the best time to intervene.

Positron emission tomography (PET) scans, which measure the levels of specific molecules, like glucose, in the brain, have been investigated as one tool to help diagnose Alzheimer's



Jae Ho Sohn, MD, MS; above, right: a PET scan of the brain of a person with Alzheimer's disease. Image by National Institute on Aging

disease before the symptoms become severe. Glucose is the primary source of fuel for brain cells, and the more active a cell is, the more glucose it uses. As brain cells become diseased and die, they use less and, eventually, no glucose.

Other types of PET scans look for proteins specifically related to Alzheimer's disease, but glucose PET scans are much more common and cheaper, especially in smaller health care facilities and developing countries, because they're also used for cancer staging.

Radiologists have used these scans to try to detect Alzheimer's by looking for reduced glucose levels across the brain, especially in the frontal and parietal lobes of the brain. However, because the disease is a slow progressive disorder, the changes in glucose are very subtle and so difficult to spot with the naked eye.

To solve this problem, Sohn applied a machine learning algorithm to PET scans to help diagnose early-stage Alzheimer's disease more reliably.

"This is an ideal application of deep learning because it is particularly strong at finding very subtle but diffuse processes. Human radiologists are really strong at identifying tiny focal finding like a brain tumor, but we struggle at detecting more slow, global changes," says Sohn. "Given the strength of deep learning in this type of application, especially compared to humans, it seemed like a natural application."

To train the algorithm, Sohn fed it images from the Alzheimer's Disease Neuroimaging Initiative (ADNI), a massive public dataset of PET scans from patients who were eventually diagnosed with either Alzheimer's disease, mild cognitive impairment or no disorder. Eventually, the algorithm began to learn on its own which features are important for predicting the diagnosis of Alzheimer's disease and which are not.

Once the algorithm was trained on 1,921 scans, the scientists tested it on two novel datasets to evaluate its performance. The first were 188 images that came from the same ADNI database but had not been presented to the algorithm yet. The second was an entirely novel set of scans from 40 patients who had presented to the UCSF Memory and Aging Center with possible cognitive impairment.

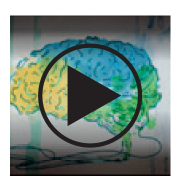
The algorithm performed with flying colors. It correctly identified 92 percent of patients who developed Alzheimer's disease in the first test set and 98 percent in the second test set. What's more, it made these correct predictions on average 75.8 months — a little more than six years — before the patient received their final diagnosis.

Next steps

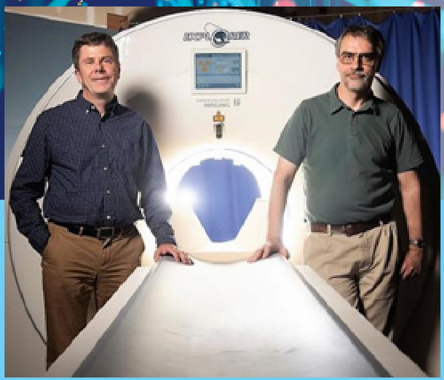
Sohn says the next step is to test and calibrate the algorithm on larger, more diverse datasets from different hospitals and countries.

"I believe this algorithm has the strong potential to be clinically relevant," he says. "However, before we can do that, we need to validate and calibrate the algorithm in a larger and more diverse patient cohort, ideally from different continents and various different types of settings."

If the algorithm can withstand these tests, Sohn thinks it could be employed when a neurologist sees a patient at a memory clinic as a predictive and diagnostic tool for Alzheimer's disease, helping to get the patient the treatments they need sooner. ■



Learn more about Dr. Sohn's research at tinyurl.com/sohnresearch (video: Brian Monroe, The Washington Post)



Project leaders Professors Simon Cherry, PhD (left), and Ramsey Badawi, PhD, next to the EXPLORER mock-up at UC Davis Health.

UC Davis

World's First Total-Body PET Scanner Installed

EXPLORER, the world's first total-body positron emission tomography (PET) scanner that can capture a 3D picture of the whole human body at once, is up and running at UC Davis Health.

Developed by UC Davis scientists, EXPLORER has already captured the attention of radiology experts around the world. It was featured in an article in Nature and its images have drawn hundreds of thousands of views on YouTube.

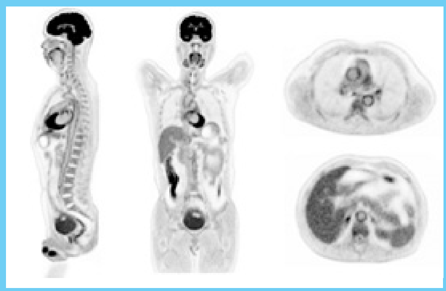
EXPLORER's exceptional image quality gives it nearly limitless potential applications for both clinical use and research, and it promises to be a game changer for the whole UC system. The first human subjects have already been scanned for a project on PET imaging of HIV originating at UCSF, and another project on Multiple Sclerosis originating at UCSD is currently progressing through IRB review.

"We are thrilled, after almost 15 years, to finally have brought this concept of total-body imaging to fruition," said co-inventor Simon Cherry, distinguished professor in the UC Davis Departments of Biomedical Engineering and of Radiology. "The first images coming off the EXPLORER scanner have exceeded what we, and I think many others in our field, thought would be possible."

The EXPLORER scanner, which combines PET and x-ray computed tomography (CT), was installed in May in a specially prepared space on Folsom Boulevard. Built by UC Davis industry partner United Imaging Healthcare (UIH), EXPLORER was shipped in two 40-foot containers to a warehouse in Oakland. From there, the parts arrived by truck in several deliveries.

EXPLORER scanned its first research subjects in the U.S. in late June 2019 and scanned its first clinical patients in August of the same year. The scanner has broad applications for cancer diagnosis, as well as for studies of blood flow, inflammation, immunological and metabolic disorders and infections. The developers also anticipate it will be useful for patients with brain diseases, heart conditions and diseases that involve multiple organs, as well as for children because of its speed and relative safety.

"We are able to see things we have never seen before," said co-inventor Ramsey Badawi, chief of Nuclear Medicine at UC Davis Health and vice-chair for research in the Department of Radiology. "I think we are going to be able to make a huge difference in both research and clinical medicine."



What's different about EXPLORER?

- The quality of the images is much better, allowing physicians to see smaller tumors and other diseases earlier.
- The scanner can be set up to run much faster than conventional PET scanners, which can make it easier and more comfortable for patients. This is particularly good for young children or patients with joint pain.
- The scanner can alternatively be set up to use much less radiation, which is helpful for children, or research where the same person needs to be scanned many times.
- The entire body can be imaged at the same time, which means it can track changes in a drug's distribution throughout the entire body, enabling an understanding of drug kinetics in every organ and tissue over time. ■

UCI

Improving Stroke Care with Artificial Intelligence

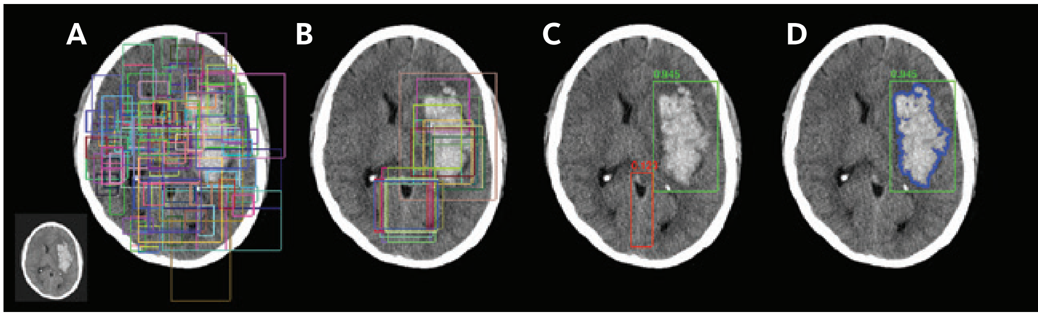


Figure 1: (A) Preconfigured bounding boxes of various shapes and resolutions are tested for the presence of a potential abnormality. (B) The highest ranking bounding boxes are identified and used to generate region proposals that focus algorithm attention. (C) Composite region proposals are pruned using non-maximum suppression and used as input into a classifier to determine presence or absence of hemorrhage. (D) Segmentation masks are generated for positive cases of hemorrhage.

The Center for Artificial Intelligence in Diagnostic Medicine (CAIDM), established by the University of California Irvine and UCI Health System in July 2018, was founded with the vision to improve healthcare with the aid of artificial intelligence (AI).

Led by Peter Chang, MD, and Daniel Chow, MD, physicians in the Department of Radiology, the CAIDM aims to both develop and deploy machine learning enabled tools into routine clinical workflow at UCI. This emphasis on translational and practical tools is one of several unique key features of the CAIDM mission:

"We aren't satisfied with just publishing our research," Chang said. "We need to go the last mile and ensure that these tools are translated into clinical practice. It's not until these applications are used in our hospitals that we can truly understand and prepare for a future of AI-enabled healthcare."

The challenge

One of the current areas of focus at the CAIDM is stroke imaging, a time-sensitive disease process where approximately 1.9 million neurons are lost every minute without proper therapy. Given the urgency to treat strokes, the American Heart Association Guidelines recommends a time to therapy initiation of 60 minutes or less. In reality, the average time to therapy was shown to be 73 minutes over a 9-year study. While some facilities have attempted to meet this challenge by improving CT interpretation times, this may be impractical for smaller community programs or even academic programs where there is very high CT utilization due to complexity of patients.

A creative solution

To meet this challenge, Dr. Chang developed and deployed an AI algorithm to automatically detect, locate, and quantify brain bleeds. In a prospective study, hemorrhage larger than 5 cm3 was detected with 99.9% accuracy. Dr. Chang, who also acts as lead software engineer of the CAIDM team, has built a career in applying new technology to medical imaging applications:

"As both a software developer and a radiologist, it is critical to balance both a realistic assessment of the current generation of AI technology with an appreciation of the problems that affect the day-to-day workflow of physicians," said Chang who holds joint appointments in Radiological Sciences and Computer Science at UC Irvine.

While most AI approaches are "black boxes," this hemorrhage detection tool combines an attention-based object detection network with more traditional classification and segmentation components. This innovative design allows the algorithm to explicitly localize suspicious CT findings and provide visual feedback regarding which findings are likely to represent intracranial hemorrhage or a mimic (Figure 1). Like much of all the work at the CAIDM, inspiration for key algorithm design choices, from multi-slice inputs to algorithm field-of-view to serial network processing, are based off of intuition arising from the interpretative process of human radiologists. As a result of these efforts, Dr. Chang was recognized by the American Society of Neuroradiology with the 2018 Cornelius G. Dyke Memorial Award for this work.

Next steps

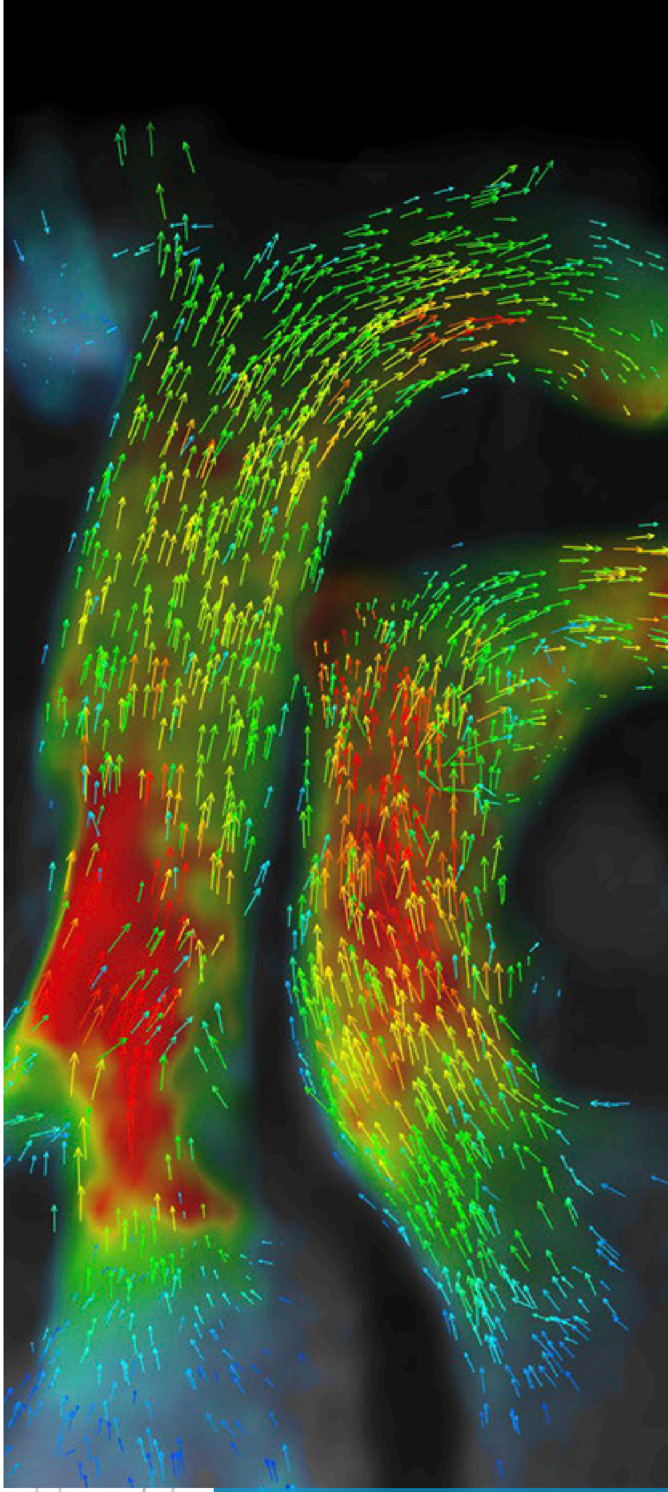
Currently, the CAIDM team is running a prospective trial evaluating the clinical impact of improved alert times at UC Irvine. In May 2019, Dr. Chang was awarded the RSNA Research Scholar Grant to expand this work to include other steps in the stroke triage pathway. He will be working alongside Dr. Min-Ying Lydia Su (Radiological Sciences, UC Irvine), Dr. Wengui Yu (Neurology, UC Irvine), and Dr. Chow for his project titled, Leveraging Deep Learning for Stroke Imaging Triage. The success of the proposed studies will advance stroke imaging capabilities by establishing a superior approach to ischemic stroke triage while also providing reliable and accurate measures of ischemic and viable tissue. ■

Read more about Drs. Chang and Chow's work at the CAIDM on page 8.

"We aren't satisfied with just publishing our research. We need to go the last mile and ensure that these tools are translated into clinical practice. It's not until these applications are used in our hospitals that we can truly understand and prepare for a future of AI-enabled healthcare." —Peter Chang, MD

UCSD

Spotlight on the AiDA Lab



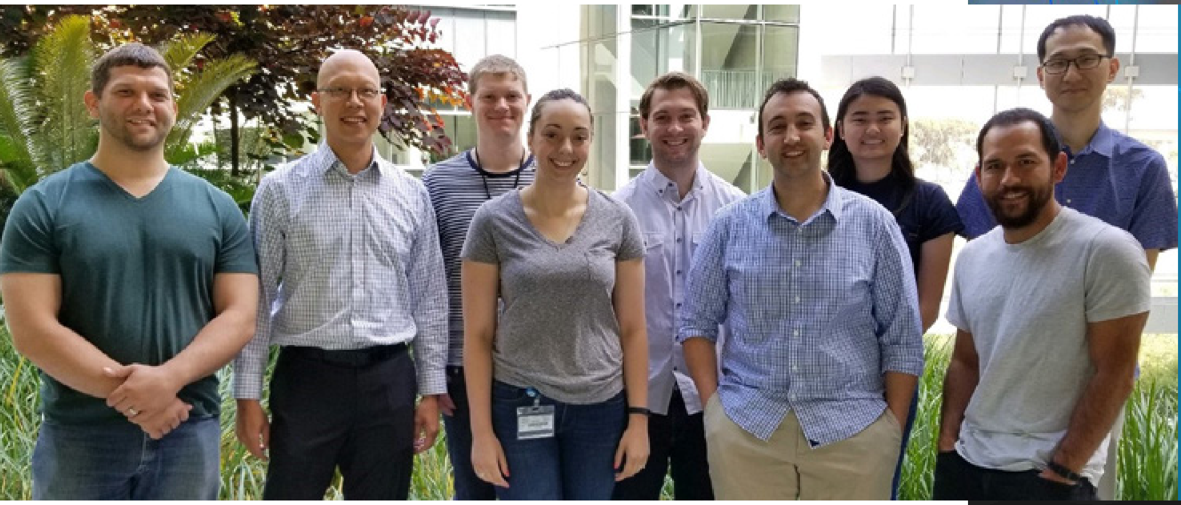
San Diego native Albert Hsiao, MD, PhD, completed his medical and graduate training through UC San Diego's Medical Scientist Training Program, followed by postgraduate training at Stanford University. During his residency, Dr. Hsiao began studying 4D Flow, a time-resolved MRI method that permits physicians to visualize not just vascular structures, but also blood-flow patterns over time.

Dr. Hsiao soon began developing and testing his own 4D Flow software, and found that the computational neural networks used in his software could allow him to accurately assess and diagnose complex cardiac problems in just a few minutes — as opposed to several hours. Based on this early success, Dr. Hsiao co-founded the cloud-based artificial-intelligence (AI) Arterys imaging platform, which has become the first FDA-approved clinical AI application.

In 2014 Dr. Hsiao returned to UC San Diego as a clinician and researcher. Now an Associate Professor in Residence and an associate director of UC San Diego Health's Center for Translational Imaging and Precision Medicine, "Triton 40 Under 40" awardee and 2019 ARRS Scholar Dr. Hsiao leads the Augmented imaging/Artificial intelligence Data Analytics (AiDA) lab based at UC San Diego's Altman Clinical and Translational Research Institute. There, over a dozen researchers focus on building new imaging techniques and deploying a "multi-omics" approach in such diverse areas as improving MRI acquisition quality, and expanding technologist training. AI is at the heart of much of this work, with the goal of using newly developed techniques and methods to help in the early diagnosis and treatment of cardiovascular disease, chronic obstructive pulmonary disease, and cancer.

Dr. Hsiao and his team are actively collaborating with GE Healthcare — including Lead Imaging Scientist (Artificial Intelligence) and former UC San Diego postdoctoral scholar Naeim Bahrami, PhD — to bring AI-centric imaging prototypes to the market. Recent projects include a GE Healthcare-funded project aimed at developing a fully automated cardiac MRI prototype for deployment across multiple UC institutions, and several RSNA-funded, resident-led models using convoluted neural networks to address critical imaging questions in disease. ■

More details on Dr. Hsiao's important work can be found in the 2020 edition of Discoveries (tinyurl.com/4Dflow)*, the UC San Diego Health Sciences annual report.*



Above: With 4D Flow, clinicians can simultaneously see and measure how blood flows — how much, how fast, in what direction — in three dimensions over time, and use that information to detect abnormalities, pre-plan surgery and track treatment response.

At left: Albert Hsiao, MD, PhD (second from left), and his team.

UCI

Center for Artificial Intelligence in Diagnostic Medicine Tackles Challenges in Healthcare

In just the past decade, rapid development of new AI-enabled technologies including deep learning neural networks has sparked a drive to translate these innovative approaches in medicine.

Daily news headlines often herald this imminent future with cutting edge research breakthroughs as well as rapid investment among both academic centers and industry partners. However despite this growing interest and momentum, integration and translation of AI in the practice of radiology remains a significant challenge.

To address this demand and to take advantage of growing opportunities in this field, the University of California Irvine and UCI Health System created the Center for Artificial Intelligence in Diagnostic Medicine (CAIDM) in July 2018. Led by Peter Chang, MD, and Daniel Chow, MD, the unique vision of the CAIDM to serve as a comprehensive core resource to enable machine learning research across the healthcare system makes the UCI Center only one of only several such initiatives worldwide.

Cross-disciplinary experience

As a central hub, a key component of the CAIDM mission is to ensure that physicians and other providers are working side-by-side with experts in data science and software engineering to build the right tools for the right problems. Indeed the lack of clinical insight early in the development process has long been a historic bottleneck in translating new software technology. "Healthcare needs and challenges will be the driver of these new technologies," Dr. Daniel Chow said. "This mindset will allow us to be intentional and purposeful in the design of healthcare-related tools and studies, which are tailored to answer specific clinical questions."

Building on this theme, the need for a true collaborative, cross-disciplinary experience has been another important emphasis at the CAIDM. Rather than simply bringing together experts in clinical medicine and data science, the CAIDM team works actively to blur the traditional boundaries that exist between the Schools of Medicine, Engineering and Computer Science. This includes a number of educational experiences and workshops to train the next generation of physician engineers and medical data scientists led by Dr. Chang, who also teaches artificial intelligence and image processing classes in the Department of Computer Science. These programs aim to highlight the unique challenges posed by medical imaging problems. For example, compared to datasets used by industry, mammograms used for breast cancer detection are high bit-depth, extraordinarily densely sampled images containing up to 24 million pixels each, yield up to a 400 fold increase in complexity. In addition, rather than tackling generic problems without a clear path for clinical integration (e.g. cancer detection to replace human radiologists for screening mammography), data scientists are taught to focus on tasks with a tangible, immediate benefit (e.g. improved model for breast cancer risk to personalize imaging recommendations).

Scalable resources

Finally, the CAIDM hopes to play an important role in the growing efforts to coordinate larger, multi-institutional projects spanning several UC campuses. In just the past year, multiple such cross-UC projects have been started with support from the CAIDM including: evaluation of non-contrast head CT exams in the emergency setting; assessment of parotid tumors on CT; characterization of renal cell carcinoma on CT; characterization of prostate cancer on MR; and identification of support devices on chest radiographs. In addition to these specific projects, the CAIDM is actively working to compile its core technologies such as image anonymization, web-based annotation, distributed learning and algorithm deployment with those from other UC campuses to build a single shared platform for the entire system. "Across the world, we are seeing a consolidation of resources across industry leaders and entire national health systems," says Dr. Chang. "With the talent and capacity here in the UC system and the state of California, there is no question in my mind that together we can be leaders at the cutting-edge of AI technology in healthcare." ■

For more information: caidm.som.uci.edu

Top Row: Peter Chang, MD (left) and Daniel Chow, MD
Middle Row: Jake Akers (left), Shreya Bhatnagar, Chanon Chantaduly, and Blanca Guardado
Bottom Row: Anna Alber (left), Melissa Khy, and Mazaya Soundara

UCSF

Artificial Intelligence Center Launched to Advance Medical Imaging

The UCSF "Intelligent Imaging" Hub will harness computational tools in medical imaging to improve patient care.

Radiology Vice Chair Sharmila Majumdar, PhD (center), who will run the Center for Intelligent Imaging's operations, discusses artificial intelligence aided images with colleagues. Assistant Professor of Clinical Radiology Javier Villanueva-Meyer, MD (left), and computational research data scientist James Hawkins (right).

UC San Francisco is launching a new center to accelerate the application of artificial intelligence (AI) technology to radiology, leveraging advanced computational techniques and industry collaborations to improve patient diagnoses and care.

The Center for Intelligent Imaging, or ci2, will develop and apply AI to devise powerful new ways to look inside the body and to evaluate health and disease. Investigators in ci2 will team with Santa Clara, California-based NVIDIA Corp., an industry leader in AI computing, to build infrastructure and tools focused on enabling the translation of AI into clinical practice.

"Artificial intelligence represents the next frontier for diagnostic medicine," said Christopher Hess, MD, PhD, chair of the UCSF Department of Radiology and Biomedical Imaging. "It is poised to revolutionize the way in which imaging is performed, interpreted and used to direct care for patients.

"The Center for Intelligent Imaging will serve as a hub for the multidisciplinary development of AI in imaging to meet unmet clinical needs and provide a platform to measure impact and outcomes of this technology," Hess said. "The result will be more efficient, higher-value imaging for patients within and outside of UCSF."

UCSF has been a long-time leader in medical imaging, dating to the development of the MRI and the university's 1975 collaboration with industry to install the first MRI systems in the United States and worldwide. The center aims to enable the same type of transformation via intelligent radiology, with the goal of again collaborating with industry to become of the first institutions to bring medical imaging AI to the bedside.

NVIDIA engineers and data scientists will work alongside UCSF investigators to develop clinical AI tools, applying powerful computational resources that are available in few medical institutions, with the goal of accelerating the AI development cycle and integrating it seamlessly in the clinic.

Tools of the future

"AI is one of the greatest tools of this century," said Abdul Hamid Halabi, director of healthcare at NVIDIA. "ci2 is bringing together an innovative ecosystem of startups, vendors, UCSF's thought leadership in radiology, and NVIDIA's Clara platform on the world's fastest GPUs, to create imaging AI solutions for improving patient care."

Researchers in the center will use patient images and clinical data from UCSF Health and other institutions to develop, test and validate deep learning algorithms. The center's computational infrastructure includes NVIDIA's DGX-2 supercomputer, one of the first to be installed in the medical community.

"The volume of medical imaging has been rapidly increasing and radiologists are struggling to keep up with the sheer number of images," said Sharmila Majumdar, PhD, a professor and vice chair in the UCSF Department of Radiology and Biomedical Imaging. "ci2 aims to impact the entire value chain of imaging, from the time the patient comes for a scan to the final delivery of individualized, quantitative, prognostic and care-defining information."

Majumdar, who will run the center's operations, will be leading a study funded by the National Institutes of Health to evaluate chronic back pain in the center, using AI-fueled algorithms, data analysis, quantitative sensory assessments, brain imaging, and biomechanical evaluation of the spine.

The center also will link academic innovation to startups to promote collaborative AI imaging research and development. The inaugural start-up company to leverage ci2 in this capacity is London-based Kheiron Medical Technologies, Ltd., which will work with the UCSF breast imaging group to ensure that its Mia™ breast cancer screening software can be safely and feasibly deployed in ethnically diverse populations.

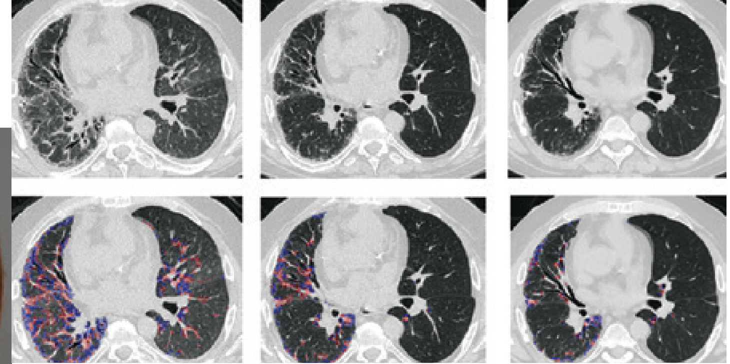
"Breast cancer affects every woman's life, either directly or indirectly," said Bonnie Joe, MD, PhD, professor of radiology and chief of breast imaging in the department. "The impact of AI is magnified through its application to breast imaging. Augmenting the radiologist's ability to detect breast cancer early will help us make a dent in this deadly disease."

"ci2 is unique in its focus of accelerating the translation of AI from the laboratory to the bedside, putting AI software through its paces to make sure it is safe and effective for patients," said Peter Kecskemethy, chief executive officer of Kheiron Medical. "Together, we believe we can help usher in a new age of cancer care when AI-supported cancer diagnostics and workflows enable doctors to provide earlier and more accurate detection and tracking, and better outcomes for patients across the globe." ■

UCLA

AI Quantification of Lung Fibrosis Outperforms Visual Extent Analysis of Images

Grace Hyun J. Kim, PhD



Above: A subject with improvement over time: 62 year old male, QLF (recadp+acbitylu ime)p rsovceod rbey 22%. in the whole lung=27% at visit 1; later QLF=7.7% at visit 2; and QLF=6.4% at visit 3. After visit 3, The percent predicted forced vital capacity improved by 22%.

Researchers at UCLA helped to pioneer an artificial intelligence algorithm over 10 years ago that adds quantitative analysis to the visual image analysis of computed tomography (CT) images at our institution in screening patients for interstitial lung disease (ILD) and for tracking changes to lung tissue over time to help manage treatment.

The Quantitative Lung Fibrosis (QLF) score was developed to bring uniformity to the interpretation of CT lung images. A significant goal of the efforts was to make the interpretation of CT images generalizable across different imaging sites and CT equipment. Once the images are normalized, the computer model analyses each voxel to determine the likelihood of fibrosis at every point in the image. A voxel represents a position in three-dimensional space just as a pixel represents a position in a two-dimensional image.

Each voxel is classified using artificial intelligence according to the distinctive visual patterns characteristic of fibrotic tissue in ILD — including ground glass opacities (which indicate inflammation) and honeycomb cysts (which are the final stage of ILD). The voxel score is summed across the entire scan to arrive at the Quantitative Lung Fibrosis score. The QLF score is expressed either as a percentage or volume in milliliters of fibrotic tissue detected. At UCLA, QLF scores have supplanted quartile scores of lung fibrosis assigned by radiologists based on their visual assessment of CT scans. QLF offers advantages in sensitivity, reproducibility and traceability. It can detect smaller increments of change and enables clinicians and researchers to track where changes to tissue have occurred over time.

In clinical investigations of fibrosis treatments for example, QLF enables researchers to track physical changes over time in patients receiving different treatments regimens. Similarly, QLF provides clinicians detailed analysis of lung tissue to help guide their treatment decisions

Development of the QLF score

The QLF score was developed using support vector machine, a supervised learning principle in which experienced radiologists identified patterns of lung fibrosis to teach the model the specific texture features of lung fibrosis. Once the model was trained to characterize each voxel, it was tested to confirm that the score based on individual voxels corresponded well with evaluations of the overall lung performed by a consensus of expert radiologists. The level of concordance between QLF and the expert consensus is 0.96, with 1.00 being perfect concordance.

Following that confirmation of the model's validity, the algorithm was further assessed by applying it to other, larger populations of patients to ensure that the score was accurate across multiple patient populations and imaging manufactures. The score was compared against both visual image analysis and lung functions test data. Researchers confirmed that changes in the score were associated with other treatment outcome measures and symptom as well. In one example, skin biopsies of patients whose lung fibrosis is associated with scleroderma were evaluated to confirm that changes in scleroderma tissue in response to fibrosis treatment corresponded with changes to the QLF score. Serum biomarkers have also been used to correlate QLF score with measurable biological changes.

QLF scores can predict changes in lung function

An exciting application of QLF is its use in adjusting the medical treatment of patients with idiopathic pulmonary fibrosis (IPF). "We have learned that changes in QLF score — whether a reduction or a worsening of the fibrosis — predict by 18 to 24 months changes of the lung function in IPF patients," states Grace Hyun J. Kim, PhD, associate professor of Radiology & Biostatistics

at UCLA. "Patients can be baselined and then tested again after six months. When their scores worsen, it may be a signal to increase medication doses or to switch medication in an attempt to prevent lung function from worsening." Conversely, when QLF scores improve, pulmonologists can consider reducing doses to minimize unwanted treatment side effects.

QLF scoring is also an important tool for monitoring rheumatoid arthritis patients for the development of interstitial lung disease. An estimated one in 10 rheumatoid arthritis patients will develop ILD over the course of their disease, leading to a significantly higher risk of mortality. It is important to define a threshold for treating lung disease in this population, and QLF scores proved the sensitivity needed to determine such a threshold.

UCLA is currently the only center on the West Coast that offers QLF testing. ■

UCLA

Device Placement Confirmation System Aims to Bring AI into Clinical Setting

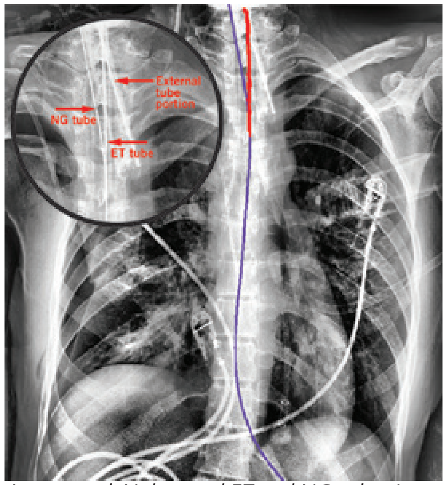
Researchers developing artificial intelligence systems at UCLA are giving special priority to projects that can improve patient care in the near term.

"While we're interested in publishing academic papers on the performance of artificial intelligence and recognize the importance of doing so, our primary focus is in getting the technology into clinical practice where it's helping physicians and it's helping patients," explains Matthew Brown, PhD, professor and director of the UCLA Center for Computer Vision & Imaging Biomarkers. Despite the groundswell of interest in medical applications of artificial intelligence, most radiologists do not make use of it in their everyday practice.

Among the current Center for Computer Vision & Imaging Biomarkers efforts that aim to address that focus is a chest X-ray device detection and placement confirmation project. A very large number of chest X-rays are performed each day to check the placement of endotracheal tubes and nasogastric tubes to confirm that they are in the correct position. Physicians need to know immediately when the placement is incorrect because of the significant morbidity and even mortality associated with incorrect placements. The high volume of these X-rays and the challenge of getting busy radiologists to review films quickly makes this application ripe for enhancement with artificial intelligence.

Two artificial intelligence knowledge representations used

The project employs a deep learning technique that applies neural networks to learn through the analysis of large amounts of data. Hundreds of endotracheal and nasogastric tube



Automated AI detected ET and NG tubes in a complex image with superimposed external leads and tubes.

images have been annotated as training samples to facilitate that learning, and ultimately thousands more will follow to build an algorithm that can analyze new images with a high degree of accuracy. While hundreds of annotated images may suffice to develop the basic functionality of an algorithm, squeezing additional performance out of the model takes progressively larger numbers of training samples. The nearer the model approaches perfect accuracy, the more difficult are the additional gains.

The system must learn to identify the tubes and analyze their relationship to key anatomical landmarks to confirm that their placement is within the targeted area. The neural network builds its model by encoding image features into a large network of nodes, where the weights between nodes are learned from training samples. This type of machine learning is very powerful, but its workings are not visible to the researchers developing the AI tools, making it in some ways difficult to interpret and also to directly enforce known anatomical relationships. The UCLA team countered that weakness using the novel arrangement of embedding the neural network in a semantic network that can described anatomic relationships. For example, they used the semantic network to specify target boundaries for correct placement of the tip of the endotracheal or nasogastric tube relative to anatomic landmarks, rather than relying on the neural network to correctly learn these boundaries on its own. In a number of ways, the semantic network layer adds assurance that the analysis will not be derailed by basic errors of interpretation on the part of the neural network.

Adding artificial intelligence to the existing workflow

Dr. Brown and his colleagues plan to introduce their placement confirmation tool directly into the existing X-ray workflow by integrating it into the PACS. "If you run the algorithm on a separate workstation, fewer physicians will make the time to use the tool," states Dr. Brown. "By integrating it into the PACS, we can run the analysis automatically for every chest X-ray at the time it is archived and make the results immediately available to the physician when they first review the image."

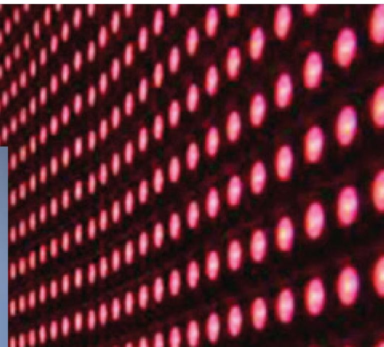
Matthew Brown, PhD

Another advantage of this integration is that the AI algorithm can be implemented simultaneously throughout the health care system, there's no need to roll out new workstations in each clinic location.

The system's findings, including alerts if the tube is misplaced, are overlaid on the X-ray image, making it easy for the physician who placed the endotracheal or nasogastric tube to preliminarily confirm its placement even before the radiologist reviews the film. The AI tube location overlay is also visible to assist the radiologist in interpreting the image. Should the radiologist discover an error in the algorithm's analysis, the image is flagged and fed back as a training sample, further refining the algorithm over time. The AI system can also identify images in which the neural network has lower certainty in its output, and can move them to the top of the radiologist's queue for immediate review. ■

UNIVERSITY OF CALIFORNIA

UC HEALTH RADIOLOGY



SAVE THE DATE:

UC Irvine to host the 2020 UC Artificial Intelligence in Radiology Conference

OCTOBER 15–16

After a widely successful inaugural event at UCLA last fall, UCI will host the second annual UC Artificial Intelligence in Radiology conference.

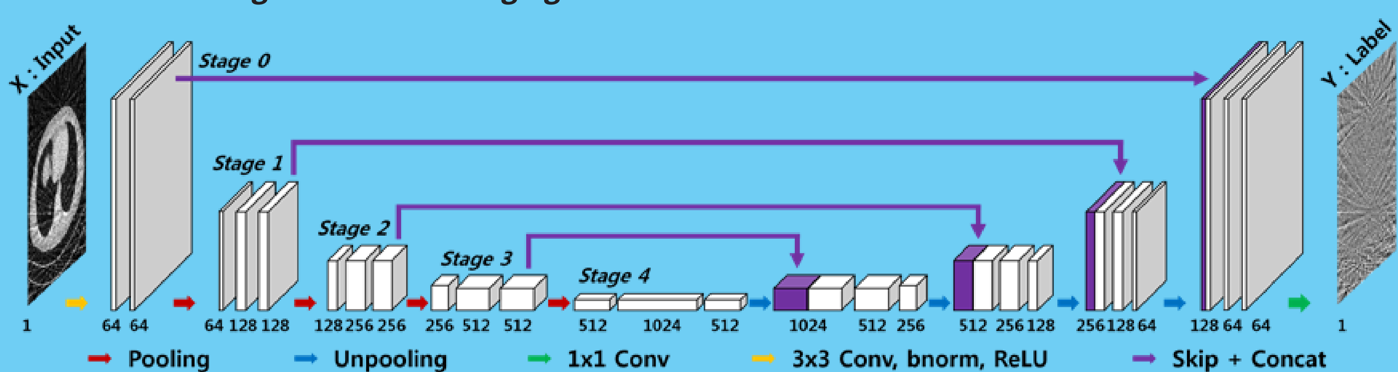
The initial event, drawing participants from five UC academic medical centers, highlighted the strong cross-campus collaboration and enthusiasm for AI in radiology. In addition to providing a platform for UC clinicians and scientists to highlight their cutting-edge work, the two-day event allowed investigators from all five campuses an opportunity to bridge new partnerships — paving the path for shared datasets, resources and ideas. The second day of the conference concluded with a series of small group strategic discussions with leadership from all five UC radiology departments to brainstorm a joined vision of close collaboration spanning research to clinical deployment of AI-enabled tools.

On the agenda for the upcoming event this year:

- Building on last year's momentum by formalizing a platform to share infrastructure, data and tools between campuses.
- Highlighting burgeoning imaging projects spanning multiple UC campuses.
- Discussing the role for federated as well as distributed deep learning in the UC system.

With the vast resources and talent between the UC campuses, there is a tremendous opportunity now to be a preeminent leader in this exciting and rapidly innovating field of AI in radiology — we welcome and look forward to hosting the UC community in Irvine, fall 2020! ■

Machine Learning Processes in Imaging



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