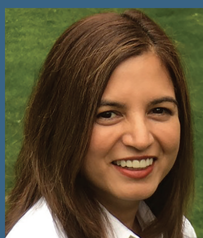
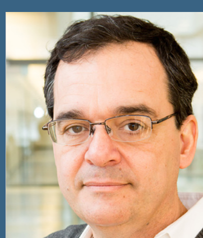
The impending "3D transformation" of radiology informatics



Shella Farooki, MD, MPH



Jonas Almeida, PhD

Mary Morrison Saltz, MD

Shella Farooki, MD, MPH; Jonas Almeida, PhD; and Mary Morrison Saltz, MD

Dr. Farooki is CEO of S. Farooki, Ltd., in Dublin, OH; Dr. Almeida is Chief Technology Officer in the Department of Biomedical Informatics at Stony Brook University in Stony Brook, NY; and Dr. Morrison Saltz, is Chief Clinical Integration Officer, Chief Medical Information Officer, and Chief Medical Lead for DSRIP at the Stony Brook Cancer Center, Chief Clinical Integration Officer for Community Practice Initiatives and Assistant Clinical Professor of Radiology at Stony Brook University Medical Center in Stony Brook, NY. *The authors would like to thank Viju Sebastian, Group Manager of Data and Analytics at Avanade in Atlanta, GA, and Bruce L. Fleishman, M.D., F.A.C.C., System Ombudsman for OhioHealth Cardiovascular Service Line in Columbus, OH.*

As radiologic scanners evolve, the size of imaging datasets continues to grow. Big Data has been used for several years to describe the phenomenon of data that is too complex or is of too great a volume for traditional computational methods to process. We are acquiring and storing huge volumes of imaging data, but ultimately to what purpose? What should we do with the overwhelming amount of real-time data? How do we go beyond vaulted data analysis to constructing information for change? What can we learn from data about our data, or radiology metadata? Radiology can benefit greatly by leveraging today's technology explosion, yet radiologists seldom engage in developing, driving, and directing this process.

As radiologists, digital imaging is ingrained into our practice, and we need to play a more active role in understanding the database architecture and analytical side of our profession. It is our responsibility to become more cognizant of and more involved in the technology that surrounds us. Radiology informatics as we know it is in the midst of transformation. We are moving toward more robust and integrated dashboards, and our specialty is becoming more integrated with other specialties. The opportunities for our involvement are numerous, and here we identify three potentially impactful domains where we can most effectively collaborate to advance technology and improve care: Drive, Development and Direction, or the "3D's" of successful, interactive technology transformation for radiology.[1]

Drivers of change

Radiologists must be the ones to lead the technical revolution and influence change in our field. It is critical that radiologists understand how we and our current capabilities fit into the technological puzzle of healthcare. This consciousness allows us to think differently, to formulate ideas and instigate change via collaboration and research, and to question innovatively. If we remain in the darkroom, we cannot imagine possibilities. Ask how you want your practice to change or how your practice can be improved using artificial intelligence (AI) or predictive analytics (PA). Be inquisitive about how, why, and where your data is stored and what the possibilities can be for its use. Perhaps we can use new technology to improve how disease-specific radiology-pathology results are diagnosed and communicated with clinicians, or how this information is communicated to patients through educational software. Maybe we want to develop decision-support algorithms specifically for radiologists so that we have more information when interpreting an examination, or perhaps we want to improve upon automated segmentation of images to fine-tune computer-aided diagnosis (CAD). We also need to propel radiology metadata beyond DICOM to other areas such as quality and safety. As radiologists, we best understand the what, where, why, and how of doing our jobs better, and we need to be the ones driving data processes and leveraging our current technology. Unless we are involved at the grassroots level, the technology will develop around us, not for us.

Involvement in development

Most radiologists don't code, but as the "domain experts," we must partner with developers at an early stage to ensure that our needs and our workflow drive the technology, and not the reverse. For the technology inclined, coding boot camps, conferences, and immersive programs are emerging everywhere, offering us the opportunity to test the new waters of data-intensive analytics for biomedical applications. The need for a translator between the clinical and technological realms gave birth to the Informatician, one who can collaborate and provide direction to move technology forward.[1]

Data science has enormous implications for healthcare delivery and public health in terms of population health strategy, research, communication, patient engagement, utilization, and disease prevention. Public health registries, syndromic surveillance, the insurance industry, research, the pharmaceutical sector, healthcare providers, the electronic health record and patients (via mobile health and social media) all make up enormous disparate sources of healthcare data. Connecting these data sources is crucial if we are to create actionable information. Integrating radiologist interpretations and radiologic data into this bigger picture is an important new frontier, making our reports increasingly relevant. Imaging data can be tied to predictive analytics to prognosticate events such as readmission or disease recurrence or risk.

New technologies can also foster different and improved communication and image sharing among radiologists, referring physicians and patients. In the future, CT and fluoroscopy data could be auto-populated into the American College of Radiology (ACR) Dose Index Registry (DIR) and then shared with the Environmental Protection Agency registry, RadNet, or Nuclear Regulatory Commission so that radiation dose can be correlated with diseases and cancer risk, for example. Inexpensive data storage makes available great volumes of previously unattainable or discarded data, also known as data exhaust, which may reveal new insights beyond the original intent.[2]

In this era of scalable computing environments, we can process, store, and analyze very large quantities of data via different platforms, and each architecture confers certain advantages and challenges. These modalities, some cloud based, are the basis for AI, machine learning, and PA and allow, for example, millions of images to be analyzed extremely quickly. Data lakes have been developed to allow multiple types of data to be pooled together, without over curation, to allow data to be tapped when needed. Real-time stream processing permits large amounts of data to be accessed on the fly, without the need for local downloads. Remember how long it took to scroll through a trauma CT of 2,000 images? These newer platforms can perform intense computational algorithms, view data from multiple different perspectives, and combine, compare, and share exceptionally large data sets in applications such as IBM Watson for Oncology and Google Flu Trends.[2]

Deep machine learning and predictive analytics are allowing researchers to analyze continuous real-time data in an attempt to discover previously unrecognized risk factors/trends, and implement intervention prior to an event. Recently, predictive modeling of cardiac MRI data has been used to predict which patients are the best candidates for implantable cardioverter defibrillators.[3] The application of our data is evolving from anatomic detail to physiology and risk stratification.

Imagine new directions

Where can we go with all of this? Grasping a high-level view of the possibilities will ensure we understand how to leverage these evolving technologies. Imagine the implications of AI, global image exchange, an international teaching file of cases, and Big Data contributing to the existing registries at the ACR such as the Radiology Data Registry or the DIR. Data science can also facilitate epidemiologic research of multi-year studies or situations where randomization would be unethical. In terms of AI, CAD, and deep machine learning, their use in radiology is relatively new. Deep learning can help radiologists by compensating for fatigue and missing critical findings. CAD can benefit not only by acting as a safety net but also by "growing" smarter so that abnormalities are detected more accurately. Metadata analytics has far-reaching implications for imaging stroke, breast cancer, or vascular disease. Chest radiographic data and accompanying radiologist report data can be combined with clinical data and then integrated with syndromic surveillance platforms such as BioSense to provide more robust real-time data and earlier detection during outbreaks.

Radiomics is a new field that involves high-throughput extraction of the quantitative data from imaging studies such as MRI, CT, or PET to better understand tumor pathology and phenotype; it has tremendous potential in cancer genetics. Additionally, integration with databases for oncology clinical trials and cancer genomics will complete the loop. Utilizing radiologic data to help predict clinical outcomes in other fields is an exciting prospect, and we are headed toward increased integration amongst specialties. Data mining and analytics can connect imaging data to genomic research and clinical trials, resulting in increasing integration of radiology, radiomics and genomics. Wouldn't it be useful to target, based on patient demographics, history, imaging, and genetics, the best candidates for certain imaging screening tests, or utilizing imaging data to determine which patients would benefit most from intervention?

Fast Healthcare Interoperability Resources (FHIR, "fire") is a new standard that allows interoperable exchange of information between electronic health records (EHRs), opening a floodgate of data exchange into and out of EHRs, which have to date been closed systems. The concept of mobile-first data analytics delivery through app development across a variety of platforms is transforming our ability to have the right data where and when we need it, in a digestible and actionable form. In oncology, quantitative assessment of treatment response can be correlated with the patient's imaging studies, which can then be linked with ongoing adjustments in treatment as well as linked to histopathology and genomics.[4,5]

As we move toward personalized imaging and healthcare with greater integration of clinical, laboratory, and radiology EHR data, there is also the potential to integrate other databases. Imagine not only having a detailed patient history but also a synopsis of the patient's entire health history, predicted diseases or risk factors, and laboratory results displayed in an infographic right on the workstation. Quality and patient safety will also be reshaped by real-time dashboards that visualize quality metrics and business processes. The algorithms and communication for decision support will evolve, we will discover new ways to archive radiology images, we will have robust analysis for tracking ACR appropriateness criteria, and we will be able to predict which patients will have contrast reactions.

In the past, we have proclaimed with complacency that we were at an exciting time in healthcare. With the digital age in full swing, that proclamation is not only true now, but will also be ever-evolving. As radiologists, we need to be mindful and more involved with how imaging data is being stored, analyzed, integrated, and applied from the bench to the reading room, and as a specialty we need to be at the forefront of and attuned to the information industry. We need to start bridging the gaps between clinical practice and informatics, recognizing that radiology informatics is undergoing remarkable transformation, and to start looking at our practice in "3D."

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