Editorial

Augmented intelligence: A synergy between man and the machine

The synergy between humans and artificial intelligence (AI) is emerging as an effective weapon to address the current blemishes of medicine. These blemishes include poor predictive power, susceptibility to fatal diagnostic and therapeutic errors, unintended consequences of empirical decision-making and inefficient hospital workflows, resulting all-too-often in suboptimal patient care. AI is on track to revolutionize how urologists will care for their patients.

AI comprises the science, engineering, and development of systems that exhibit the characteristics which mimic human intelligence and behavior. Effective AI involves distinct insights in perception; in pattern recognition for text, speech, and images; in decision-making and for problem-solving. Rapid strides have been made in developing synergistic human-machine systems that exploit the positive aspects of human and AI-generated reasoning. It is, therefore, important for urologists to understand the current clinical applications of AI and its imminent impact on their practice in the coming years.

At a high level, AI consists of four subfields that are leading to applications in health care:

1. Machine learning (ML): statistical techniques-based programming, which enables computer systems to learn and recognize patterns to make predictions without being explicitly given the instructions for how to do so
2. Natural Language Processing (NLP): the techniques to build computer power to achieve a human level of understanding of different languages. Language translation, text analysis, and speech recognition are some applications made possible through NLP
3. Artificial Neural Networks (ANNs): it comprises computer programming to mimic biological nervous systems. Deep learning (DL) is the most recent iteration of this concept, comprising multiple layers of computer-generated neurons, which together have the ability to recognize more complex and subtle patterns than ever before
4. Computer vision: through which machines learn to understand the data within radiologic and pathological images and endoscopic videos. With significant "training," AI has already been shown to equal or exceed the current human level expertise to recognize tumors found within diagnostic images.[1]

DL currently being applied to autonomous vehicle technology is another example of the enormous untapped potential AI has for medicine. With new programming, DL could be used for influencing patient care outcomes in positive ways. Autonomous driving is made possible thanks to an incredibly large amount of real-time traffic data, maps, and a myriad of live, real-time sensors aboard a vehicle monitoring surrounding road conditions. This constant stream of data enables the AI on-board the car to make instant crucial decisions unassisted by a driver. Each autonomous car also continually transmits information to a central cloud for statistical optimization as a feedback loop for its algorithms.[2] This technology currently in use evinces promise for future application of DL to make surgery safer through AI-driven intelligent robots capable of steering surgeons through complex surgical tasks smoothly making the use of volumes of data difficult to assimilate otherwise. As of now, such high-end DL applications in medicine are still in infancy. The Mako joint replacement robot is an intelligent robot which guides surgeons in planning and executing a personalized procedure for each patient with highly predictive postoperative outcomes.

Patient records generate a staggering amount of data during the health-care process, through wearables and trackers; in digital and paper forms found within electronic medical records; in high-resolution radiologic, endoscopic, and histopathology images; and from the genomic information gathered during illness and recovery. This accumulated big data, when analyzed with AI, has an enormous potential to provide clinicians with an enlightened understanding of the patient's personalized disease pattern. AI will be able to guide clinicians with the accumulated knowledge to forecast events and to identify the windows of opportunity for possible interventions. The advent of enhanced computing power, infinite cloud storage, and modern neural network architectures has further facilitated integration and homogenization of data from a variety of sources to make clinical sense of it for the clinician.

A very logical question emerges: will machines take over human function? In the current state of the technology-the answer is "No." In medicine today, AI or similar technology is being nurtured to be complimentary to human intelligence-not to take over. This question has already been answered differently in transportation, with autonomous cars freely plying the roads of the world in limited places. It was not very long ago when full automation, defined as full control by the vehicle under all conditions-without any human assistance was forbidden. We believe that it will be only a matter of time before surgery becomes the domain of AI. Powerful new computer platforms and the cloud have enabled corporate giants, already competing with smart surgical robots in ways never seen before to begin incorporating AI into their new devices. Only time will show where these new products will lead?

Urology, a specialty heavily dependent on image pattern recognition in the diagnosis of patients with urological ailments, is likely to benefit the most with DL applications for image processing. Currently, image pattern recognition is being used in radiology, which has already improved the efficiency of the diagnosis. ML has surpassed the accuracy of humans, as reported in a study comprising 112,000 labeled chest X-ray images. When compared with the reported findings of four experienced radiologists, the AI algorithms performed much faster, and with more accuracy than the radiologists.[3] Takeuchi *et al*. applied DL to predict the diagnosis of prostate cancer on multiparametric magnetic resonance imaging as an alternative to prostate biopsy with 5%–10% higher accuracy.[4] Zheng *et al*. predicted the diagnosis of the early stage of renal cell carcinoma using nuclear magnetic resonance-based serum metabolomics and self-organizing maps.[5]

Digital pathology applies computerized image processing, plus AI analysis and interpretation of digitized images for accurate histopathological diagnosis. Convoluted neural networks have been successfully applied for diagnosing prostate cancer by pattern recognition of the nuclear morphology.[6] AI applications in the histopathological diagnosis of prostate cancer have already narrowed inter- and intra-observer variations and further improved diagnostic accuracy and process efficiency.

Wong built a predictive model using AI, to forecast early biochemical recurrence following robot-assisted radical prostatectomy. They found that AI is capable of doing so more accurately than the traditional statistical model.[7] ML has also been used to predict individual cancer patient response to therapeutic drugs.[8] In urothelial cancers, neural networks are able to differentiate benign from cancerous lower tract tumors.[9] Wang *et al*. harnessed AI to predict mortality following radical cystectomy with high accuracy.[3]

In benign urology, a prototype neural network predicted the stone-free rate of patients following extracorporeal shockwave therapy, with an accuracy of 99.25%.[10] AI technologies are also automating stone detection, stone analysis and the lithotripsy procedures, and forecasting stone recurrence.[11] Blum *et al*. used AI to diagnose early pelvic ureteric obstruction.[12] Tapak *et al*. reported that an ANN model outperformed the conventional statistical model in the prediction of kidney transplantation failure.[13]

Despite so much work being done using AI applications in urology, we are still waiting for a validated clinical practice tool with proven predictive value. It is known that receiver operating characteristic and the area under the curve commonly reported metrics to assess the performance of the predictive models are not necessarily indicative of clinical utility of models until the models have been validated in the clinical practice.[14] Recently, the food and drug administration has authorized the first autonomous AI diagnostic system in medicine. It is approved for the use of health-care providers to diagnose early-diabetic retinopathy.[15]

ML is not a magic device that can spin data into gold. Instead it is a natural extension of traditional statistical approaches.[16] High quality, dense data, and best analytic practices must be used to ensure that the end AI-derived urologic predictive model is robust, valid, and can be trusted the lives of the millions are at stake.

India, with its large population of patients with urological diseases, high level of surgical skills, and excellent infrastructure, has the edge over the rest of the world for building personalized, predictive models. These AI models have the potential to soon become applicable to Indian patients, but only if we become data obsessive. We can best accomplish this by developing a culture of measuring and capturing everything that we do to our patient. Reputable, high-quality data alone could help ensure India a respectable position in frontline research of AI applications in health care. One must remember that the introduction of new technologies in health care has not always been straightforward or without unintended adverse consequences.[17] We must insist that rigorous standards be maintained-not only for the value of the research but also to provide the most benefit to our patients as we work to make AI in medicine the new global standard of excellence.

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