Background Information

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Artificial intelligence: Transforming data into knowledge for better care

- Inspired by neural structures in the human brain, Deep Learning is creating previously unimagined opportunities in data analysis
- Digitalizing healthcare and combining the power of artificial intelligence can help healthcare providers remain competitive despite shortages of skilled staff and increasing imaging scan volumes
- Siemens Healthineers provides trained algorithms that could make work processes faster and easier for radiologists in the face of time pressure and complex cases
- As the volume and complexity of data increase – from multiple sources and across disciplinary boundaries – AI solution of Siemens Healthineers could help the entire clinical process

Increasing patient numbers, shrinking reimbursement rates and the shift to result-oriented remuneration models – the healthcare industry is facing constant change. Digitalizing the market and rapid technological progresses are accompanied by changed regulatory demands, cost pressure and growing customer expectations. Highly promising technology is opening up previously unimagined opportunities, thanks to exponential growth in computing power, huge memory capacity, and growth in networking. The key concept is artificial intelligence, or AI. Siemens Healthineers uses this technology to help healthcare providers around the world prepare for the trends affecting the sector, and has a leading position in this area. More than 400 patents in machine learning, 75 patents in the area of Deep Learning, and more than 30 AI-based applications pave the way for healthcare providers worldwide expanding precision medicine to foster individualized prevention and therapy with a precise diagnosis.

System recognizes patterns and rules

Artificial Intelligence describes the status when a machine mimics cognitive functions that humans associate with other human minds. Machine Learning makes this possible. Algorithms are trained using a large amount of annotated data. During the learning phase, the system abstracts the available information and recognizes patterns and rules in the training data – in other words, the machine draws its knowledge from data which was curated by medical experts. Once trained, it is ready to evaluate previously unseen datasets.

One form of Machine Learning is Deep Learning, which is inspired by neural structures in the human brain. The brain contains billions of nerve cells – neurons – which in turn are connected to countless other neurons via synapses. Each neuron receives specific stimuli from the others. If these are strong enough, the neuron fires and sends a signal to the next one. The result is an activity pattern: thinking. IT specialists use similar mechanisms to interpret complex data using artificial neural networks. The input data is fed in via an entry layer consisting of many artificial neurons. For images, for example, this would be individual pixel values. The following neuron layers then process this data, layer by layer, as the information becomes increasingly abstract. In the final layer, the output layer, the result of the analysis can be read out. In the training phase, the algorithm is trained and adjusted until it produces the best possible result.

In the case of the latest version of Syngo.via, such Deep Learning algorithms automatically detect and segment related structures - the heart, the main artery or the lungs - without time-consuming, manual processing. The underlying Deep Learning algorithm was trained with a variety of computed tomography data sets. Subsequently, photorealistic images are created based on the cinematic volume rendering technique. This allows even for complex data to be converted into an easily understandable visual language, which is especially for the communication with referrers and patients beneficial.

The more training data is available, the better the system can generalize the problem, and the more precise and robust the outcome can be. Today, enough medical data is available to implement complex, multi-layer networks based on extremely high computing capacities. High-quality data is the driving force behind this advance. The diagnostic process generates a massive volume of qualitative image data, lab results, and pathological and radiological findings. The quality and the combination of different kinds of data, in particular, play an important role. The more data of this nature is available for training purposes, the greater the power of Deep Learning. In recent years, Siemens Healthineers has put major efforts in expanding interpretation and annotation on a database that now comprises more than 100 million images, reports, and clinical and operative data.

Intelligent assistants for radiology

This topic can be of increasing importance for radiologists, since they too face major challenges. Every year, the Royal College of Radiologists performs surveys of all radiology units in Britain's National Health Service. Between 2013 and 2016, the organization recorded an increase of more than 30 percent in computed tomography (CT) and magnetic resonance imaging (MRI) examinations – three times as high as the growth in Radiology workforce. The same report shows that only three percent of hospital radiology departments are capable of dealing with all their patient scans during normal working hours.[1] Another study showed that the error rate for the participating radiologists was ten percent, based on an average interpretation time of ten minutes and nine seconds. If they had to interpret comparable CT images in half that time, the error rate increased to 26.6 percent.[2]

To help healthcare providers remain competitive in the face of increasing patient numbers and a shortage of skilled staff, Siemens Healthineers is working on intelligent algorithms that will ensure consistent diagnoses – regardless of the patient, the technologist or the individual assessing the image. The interpretation and prioritization of routine images – which may also be subject to a low reimbursement rate – is precisely where AI can help radiologists achieve, for example, a faster evaluation so they can devote more time to more complex cases. So what form does this take in concrete terms?

Support with routine cases

Chest imaging is a typical example of a routine case. About 35 million are performed each year in the USA alone.[3] That means the chest is one of the most frequently scanned parts of the body. The reimbursement, on the other hand, is just a few dollars at a time.[3] The solution: the intelligent assistant, which helps to interpret the material more quickly, but without overlooking incidental findings because of time pressure. In practice, the system is trained using an immense number of multi-modal chest images – until it can automatically segment and characterize the anatomy of the chest. The artificial neural network is then able to detect anomalies in unfamiliar datasets and highlight them for the radiologist. For example, based on the experience it has accumulated, the system can help detect and measure a mass in the lung, and automatically determine any changes compared to a previous scan. In the same way, it can identify and characterize calcifications and plaques in the coronary arteries, for example.

As a multi-organ region the chest is a challenge, since the images contain a large amount of information. The radiologist reads the image in terms of his own assessment as to what illness it might be. The algorithm, on the other hand, takes equal account of all regions of the chest and can alert the radiologist to incidental findings. The result of the calculations is a standardized, reproducible and quantitative report. The intelligent assistant is not a replacement for the radiologist in any sense, but helps reduce the error rate in narrow time windows.

AI close to the patient

The AI solutions from Siemens Healthineers also help the clinical process in other areas. During the scan preparation, AI provides assistance in the form of an intelligent and automated workflow in CT to generate reliable and consistent images while it reduces unwanted variations. It therefore helps avoid costly repeat scans, and save time for everyone involved. This is of great benefit to the patients, since they are spared an additional examination, also resulting in additional radiation dose exposure. This AI based workflow in CT is the new FAST Integrated Workflow[4] from Siemens Healthineers, which helps the medical assistants scan the right areas of the isocentered body with the right dose of radiation. The key is the unique FAST 3D camera, which is mounted above the scanner. It is available for Somatom Force, Somatom Drive and Somatom Edge Plus[4]. The camera records the patient's shape, position and size in three dimensions. It also uses infrared to detect the contours of the body. Intelligent, Deep Learning algorithms then use the data to achieve precise patient positioning by setting the right area of the body, the precise direction of scan and supports the isocentric positioning in the gantry.

Extracting every subtle detail from multiple data sources

Early detection of prostate cancer by multiparametric MRI is an example of how AI can augment the analysis of data from multiple sources, such as images with different contrasts, each covering different tissue properties, such as morphology, cell density, or physiological function. In this case, artificial neural networks are trained on the correlation of the multiple image inputs with expert radiologists' reports, as well as additional clinical data such as biopsy results. The great advantage of artificial neural networks is the natural support of different data types and sources. A broad range of details can be evaluated together. In the future, the system will help not just to point out prostate lesions, but also assess their level of suspicion of malignancy. In this way, it will assist radiologists with high-quality individual risk assessment of prostate cancer patients, and support a broad dissemination of the necessary expertise by shortening the learning curve and reducing inter-reader variability.

Smart algorithms can also provide direct support in the treatment phase and vast amounts of CT image data once again serve as the basis for calculation in this case. Precise treatment options like the Radio Therapy (RT) Image Suite from Siemens Healthineers which helps physicians determine the outline of at-risk organs prior to radiotherapy. Doing this manually is very time-consuming and increases the cost of treatment. There may also be minor inter-observer variations. The algorithm provides precise set of contours. RT Image Suite offers quick access, high-quality adoption of the contouring by offering a consistent starting point for clinicians designed for Radiation Therapy.

With increasing volumes and complexity of data from different sources and across a range of disciplines, artificial intelligence is the key to make medical technology smarter, image data and lab result analysis faster, and examinations more accurate.

[1] The Royal College of Radiologists: Clinical radiology UK workforce census 2016 report: https://www.rcr.ac.uk/system/files/publication/field_publication_files/cr_workforce_census_2016_report_0.pdf

[2] The Effect of Faster Reporting Speed for Imaging Studies on the Number of Misseand Interpretation Errors: A Pilot Study: http://www.jacr.org/article/S1546-1440(15)00203-3/pdf

[3] Numbers represent Medicare reimbursement only. Calculation based on 2015 Medicare reports. Sources: CMS Statistics, Journal of the American Radiology 2017:14:337-342

[4] FAST Integrated Workflow and Somatom Edge Plus are pending 510(k) clearance, and are not yet commercially available in the United States.

The features here mentioned are not commercially available in all countries. Due to regulatory reasons their future availability cannot be guaranteed.

For further information on RSNA 2017, please see our Press Feature www.siemens.com/press/rsna2017.

For further information on Artificial Intelligence,
please see the whitepaper http://www.siemens.com/ai-whitepaper
and the website www.healthcare.siemens.com/artificial-intelligence.

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In fiscal 2017, which ended on September 30, 2017, Siemens Healthineers generated revenue of €13.8 billion and profit of €2.5 billion and has about 48,000 employees worldwide. Further information is available at www.siemens.com/healthineers