Deep Learning in Radiology: Innovation in CT Imaging

The University Hospital of Jena benefits from high-end CT

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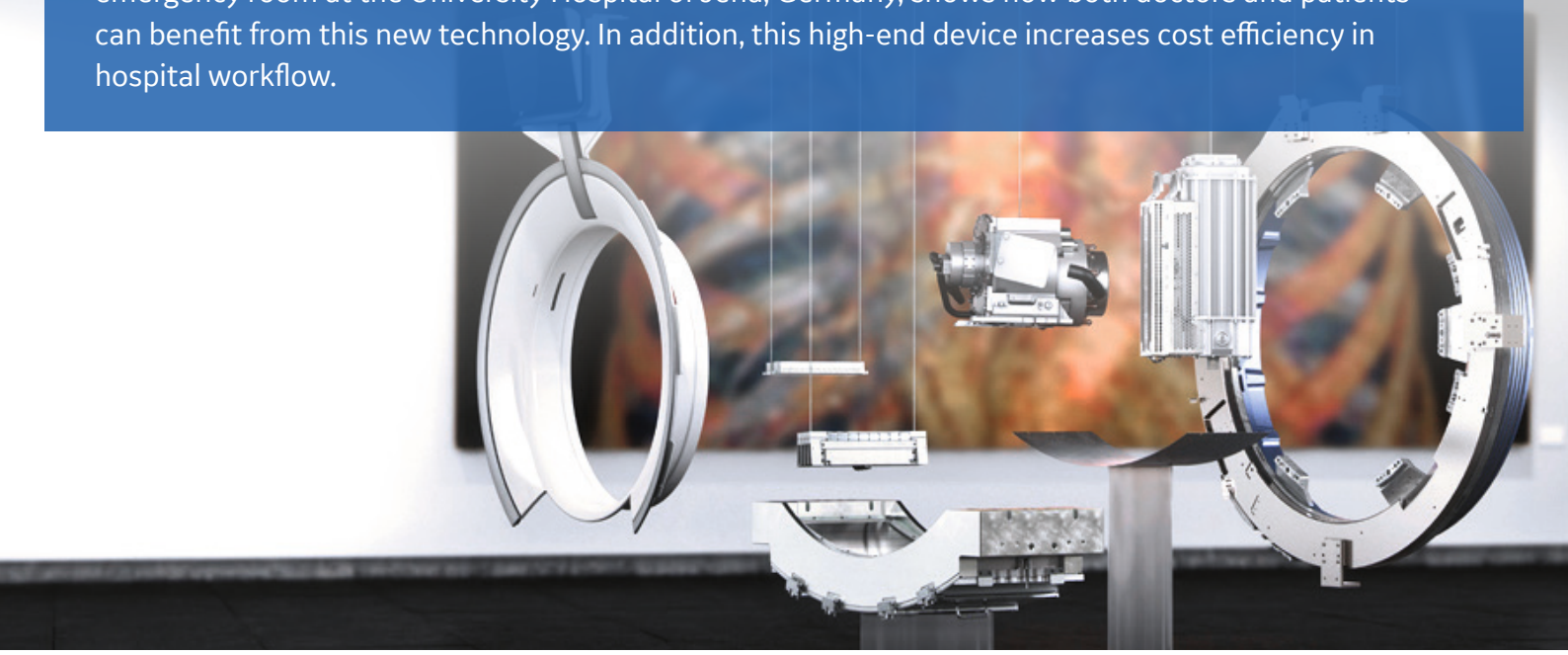
Deep Learning in Radiology

Artificial intelligence has paved the way for the next steps of innovation in CT imaging. The use of a computer tomography (CT) scanner with Deep Learning Image Reconstruction (DLIR) in the central emergency room at the University Hospital of Jena, Germany, shows how both doctors and patients can benefit from this new technology. In addition, this high-end device increases cost efficiency in hospital workflow.



The spectrum of possible conditions ranges from harmless to life-threatening: When a new patient arrives at the emergency room (ER), the medical staff has to categorize and diagnose a possible disease as quickly and accurately as possible. Worldwide, one of the top reasons for an ER visit is chest pain. But not every patient complaining of tightness, pain, pressure in the chest or shortness in breath is suffering from a heart condition such as a heart attack. "It's exactly these at-risk patients that we can screen and treat as soon as they arrive at the ER," says Professor Wilhelm Behringer, Director of the Center for Emergency Medicine at the University Hospital in Jena, Germany (UKJ).

For the past five years, this critical care provider in the east German state of Thuringia has been using GE Healthcare's Revolution CT at the Central Emergency Department – making the facility one of the pioneers in deep learning radiology. In April 2019, the hospital was one of six users worldwide to pilot artificial intelligence in the reconstruction of CT images. Thanks to artificial intelligence, this high-end CT routinely delivers very sharp images with low noise, including accurate imaging of the heart and surrounding blood vessels.

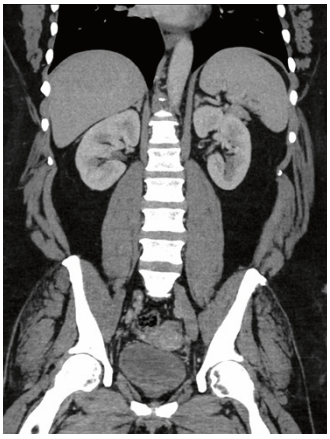
> "Together with GE Healthcare, we have developed various measurement protocols, so that now one click is all it takes to store a large volume of data correctly and make complex evaluations reusable for everyone.

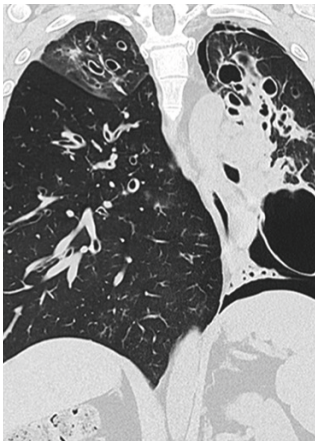
Professor Ulf Teichgraeber,
Director at the Institute of Diagnostic and Interventional Radiology

Faster and better diagnostics in radiology with deep learning

Although commissioning this CT initially required new workflows, it then sped up processes for the benefit of patients. "The CT images are much clearer than before, enabling more rapid diagnoses and an immediate start of necessary therapies," explains Dr. Ioannis Diamantis, senior physician at the hospital's Institute of Diagnostic and Interventional Radiology. "We no longer discuss artifacts or blurred images, for example, while analyzing the aorta to measure the lumen of a thrombus."

The main innovation is image reconstruction with the help of artificial intelligence: Today, "True Fidelity," a Deep Learning Image Reconstruction (DLIR), makes it possible to reconstruct data sets in an very sharp, low-noise and high-contrast manner. In the past, radiologists were used to images reconstructed with filtered back projection. However, recording these images required a much higher radiation dose in order to achieve the same quality and thus diagnostic significance. The new image reconstruction technology is integrated into a unique imaging chain with the highest technological level – from the detector element to data transmission and deep learning image reconstruction (DLIR).





DLIR is a complex form of machine learning based on a deep neural network that is particularly similar to the human brain. The network is fed with both sample data from phantom images and high-resolution patient images. DLIR then processes the information independently on several levels – and learns. During the training process algorithms are derived, adapted and further optimized. In this way, the potential of large amounts of data (big data) can be fully exploited. The fully trained algorithm is then validated and put into clinical use. In addition, the new DLIR technology keeps radiation exposure for patients and medical staff as low as possible. "Deep Learning-based reconstruction significantly reduces image noise, compared to the established model-based iterative reconstruction. In many cases we manage to reduce the standard deviation by 50%," says Felix Guettler, Financial and Technical Director at the Institute for Diagnostic and interventional Radiology at UKJ. "In the past, we had to increase radiation dose for enhance image quality. With DLIR we can significantly reduce the radiation dose, and at the same time we can achieve a better image quality and a shorter reconstruction time. We now reduce radiation dosages by 30% on average, compared to examinations without DLIR. But we are still working on optimizing the protocols. Patients with a high BMI especially benefit from this," adds Diamantis.

About **6.3 million CT scans** were performed on patients admitted to German hospitals in 2018. This reflects an increase of around **70 percent within 10 years.** With the increasing number of CT examinations, dose **reduction** for individual applications is increasingly important.

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Deep learning saves radiology costs

The decision to launch the Revolution CT was clearly also driven by economic reasons. "Many follow-up examinations are no longer necessary now, which saves enormous costs," says Guettler. Highly complex evaluations such as a three-dimensional vascular reconstruction are now standard procedures in Jena – day and night.

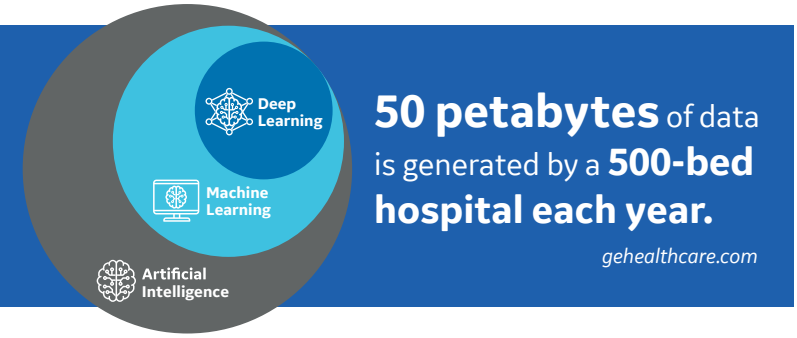
> Thanks to the new CT, only relevant – that is, really sick – patients come to us for cardiac surgery. Patients with diffuse chest pain without cardiovascular findings have already been examined in the emergency room.
>
> Professor Torsten Doenst,
> Director at the Clinic for Cardiac and Thoracic Surgery

This level of success was possible because the manufacturer regularly assisted the central ER employees on site for six months. "This extensive support after commissioning has allowed a faster exploitation of the full technical potential. Through optimized processes, we have also achieved economic advantages," says Guettler
The University Hospital in Jena now operates two Revolution CT as well as one Revolution EVO.

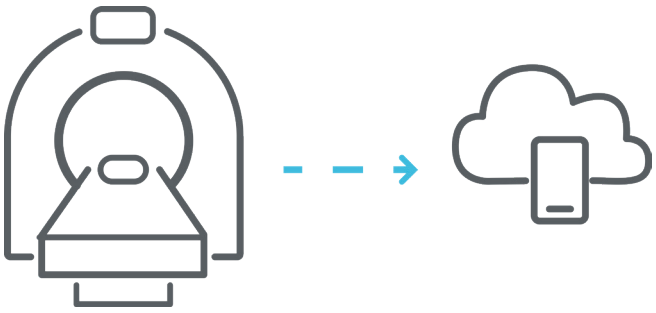
Central data storage enables follow-up evaluations

Through its equipment, GE Healthcare also has an eye on IT infrastructure. All measured data is stored securely in a digital thin-film archive as well as on the AW (Advantage Workstation) server. "This web-based solution can now be accessed and used by many members of the hospital staff,

including our residents," says Diamantis. Previously, there were only one or two workstations. This resulted in limited access and, often, additional costs for new image reconstructions such as 3D visualization. Today, GE Healthcare technicians also have remote access to the AW server and can respond quickly in case of technical issues. In addition, all measured data is archived for follow-up evaluations and future AI applications.



The associated technology platform can be expanded and scaled as required: GE Healthcare's "Edison" platform integrates all AI and analytics applications such as intelligent apps and smart systems into existing devices. Developers can find on this platform services for big data management as well as for data security for patients and physicians.



Radiology in Jena participates in deep learning development

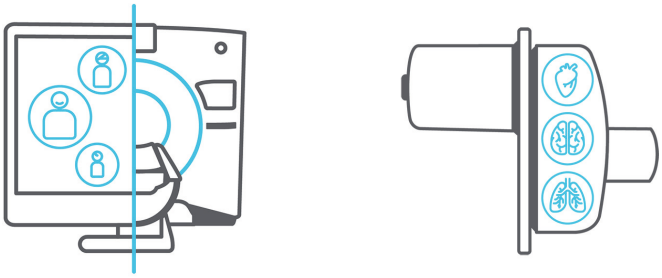
"The potential of Deep Learning in the radiology field is enormous. Thanks to DLIR, Deep Learning has now for the first time a broad influence on the clinical care at UKJ. We are in close contact with GE Healthcare. We can quickly participate in the technical development process of the CT scanners in our facility," explains Guettler, who is a computer scientist himself. The UKJ made a conscious decision to purchase two high-end CTs with an innovative 16-centimeter detector and Deep Learning Image Reconstruction (DLIR). Now, a complete heart examination takes only 0.14 seconds. The heart, aorta and lungs can be fully scanned in one second – regardless of the heart rate and almost without respiratory pauses. Each year this device performs 26,000 examinations in Jena, providing significant imaging of patients with a high pulse rate, irregular heartbeat or extreme restlessness. "We want to offer our patients and physicians real innovation. We regard this as our responsibility in medical care as well as in specialist training for physicians," adds Guettler. Medical training has a strong reputation in Jena. The introduction of the new CT scanners and of DLIR caused particular interest among the employees in the radiology department.

> We have many dedicated young doctors here, who are interested in technology. We can train them quickly and in a future oriented manner with up-to-date devices and technologies.

MUDr. Ioannis Diamantis,
Senior Physician at the Institute of Diagnostic and Interventional Radiology

A good reputation among experts and the general public

Interdisciplinary cooperation among doctors at the UKJ has also greatly benefitted from this innovation. The exchange between the emergency department and the cardiology department has grown enormously, and other departments such as oncology and vascular surgery also benefit from the new, exact imaging. "Now, we're observing a much closer communication among doctors from different departments. Mutual trust has grown, which, of course, also improves the work environment," says Teichgraeber. And word has spread far beyond Jena about how well the new diagnostics system is working – and not just within specialist circles. "We also receive inquiries from patients about the possibilities of the new, non-invasive cardiac diagnostics," explains Teichgraeber. As a result, the device is also used for outpatients in special departments. This example underlines how artificial intelligence allows doctors to diagnose medical conditions more precisely and efficiently, in the shortest time possible and on a single device.



A CT heart examination **reduces the need for a cardiac catheterization procedure from 100% to 14%** in a group of patients with suspected coronary heart disease (CHD). A CT examination was **five times more** likely to diagnose a CHD in the group of patients that received a CT examination before a cardiac catheterization procedure than in the group of patients that received a cardiac catheterization procedure directly.

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"3 Questions for..."

A short interview with Felix V. Guettler, Financial and Technical Director at the Institute for Diagnostic and Interventional Radiology, University Hospital in Jena, Germany.

Why did you choose GE Healthcare's Revolution CT for the radiology in the central emergency room?

In our work at the University Hospital, we have to meet the highest clinical and scientific requirements while fulfilling the necessary financial targets. These requirements also apply to the devices and the technologies we use, especially in the ER. Therefore, only the most innovative systems of the manufacturers were in competition.

Felix V. Guettler,
M.Sc. in Informatics

What has improved for your doctors?

We see huge potential in AI not only for image reconstruction but also for supporting clinical diagnostics. Reliable and fast technologies are important for both working results and employees' satisfaction. We must offer to the future specialists high-level training with state-of-the-art technology in order to allow them to shape the future and to have an easy access to science.

How can patients benefit from these innovations?

Our patients benefit from a better imaging as they get an accurate diagnosis from the beginning of their hospital stay. Moreover, our processes are more efficient. Now, more people can leave the emergency room and go directly back home instead of staying at the hospital. The patients are diagnosed quicker and can eventually receive their therapy sooner than in the past.

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