Formula for ultra-fast scanning

Four researchers utilized compressed sensing to cut MRI scan times dramatically.

Within the space of only nine years, the Siemens Healthineers team comprising Edgar Mueller, Mariappan Nadar, Michaela Schmidt and Michael Zenge managed to take basic mathematical research and turn it into a new and radically faster image acquisition technology for MRI scans.

They were honored for this work in the Outstanding Invention category.

**Michaela Schmidt,
Dr. Michael Zenge,
Dr. Mariappan Nadar
and Dr. Edgar Mueller**

Siemens Healthineers MR
in Erlangen, Germany
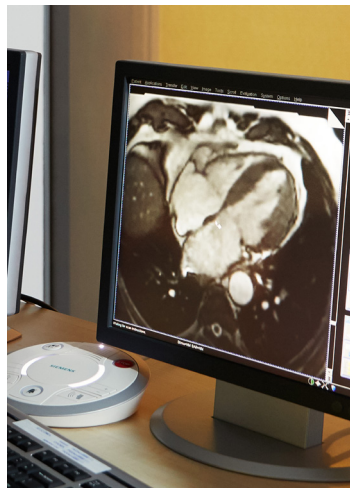
**Michaela Schmidt,
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Inventors of the Year 2017

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It normally takes several decades before a new mathematical model is actually used in an industrial application. But this was not the case with compressed sensing. After an outstandingly short development period, this mathematical model is now the reason why the time needed for MRI scans has been slashed from six minutes to less than 25 seconds. Before this, patients were forced to hold their breath for long periods in order to obtain sharp images, especially when scanning a beating heart.
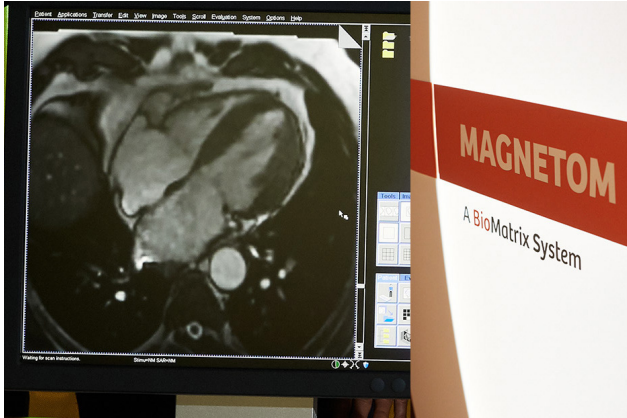
Between 2004 and 2006, research groups in the USA began to present compressed sensing as a new model for sampling and reconstructing sparse signals. Many experts were skeptical at first. The model contradicted all conventional theories about obtaining usable images from very small data samples. A compression method such as JPEG works by first acquiring a large amount of raw data and then only extracting and storing what is necessary to create the required image.

The secret to compressed sensing, expressed in simple terms, is to reduce the amount of data during the acquisition process itself. According to the new model, this sparsely sampled data will be sufficient to reconstruct the image.

At a conference in 2007, Mariappan Nadar – an expert in imaging techniques at the Siemens Healthineers research group in Princeton, New Jersey – talked to his Erlangen-based colleague Edgar Mueller – a specialist in MRI – about the possibility of using compressed sensing for MRI scanning. They decided to split the work up between them: Nadar and his group in Princeton were to be responsible for looking at image reconstruction, with Edgar Mueller and his colleagues in Erlangen examining ways of reducing the amount of sampled data. The Siemens Healthineer researchers developed new ideas for reconstructing images with a high spatial and temporal resolution despite drastically reduced data samples, particularly for real-time dynamic imaging.

Two years later, the group was joined by Michael Zenge, also a Siemens Healthineer working in Erlangen. A software engineer, he headed up the project to utilize the new model for use in MRI scanning. Once prototypes started to deliver the first usable images, it became the job of Erlangen-based Michaela Schmidt to enhance these images and have them tested by cardiologists and hospitals partnering with Siemens Healthineers. She was also responsible for optimizing the workflow used in the new scanning method. Cardiologists and clinics have been testing compressed sensing for scanning patients since early 2012. Since the beginning of 2017, compressed sensing Cardiac Cine has enabled some Siemens Healthineers MRI systems to scan a beating heart in real time at rates of more than 20 frames a second.

All four of the honored researchers and developers regard the project as one of the pinnacles of their careers. As Edgar Mueller says: "We collaborated closely over many years, despite working in different teams and on different continents." The groups, comprising far more members than those named here, came together on many different occasions – face to face or via video links – to exchange results, define subsequent steps and provide mutual encouragement. "The collaboration was the best I have ever experienced, with an extremely successful end result", states Michael Zenge. For Michaela Schmidt: „The fact that we all come from completely different areas meant each of us was able to make an important contribution and learn from each other."

Healthineers. He is now back working in Erlangen. Zenge has registered 35 inventions that are protected by 47 patents in 32 patens families.

Dr. Mariappan Nadar (52) studied electrical engineering in Mumbai, India before gaining his Master's degree in the USA. His doctoral thesis dealt with super-resolution techniques in computer-aided imaging. He was been working in Princeton, New Jersey since 1995, carrying out research into medical imaging methods, initially for Corporate Technology and now for Siemens Healthineers. Nadar developed neurofunctional imaging in collaboration with Edgar Mueller before switching his attention to compressed sensing. His current research work focuses on the use of artificial intelligence in imaging. Nadar has registered 103 inventions that are protected by 39 patents in 75 patens families.

Dr. Edgar Mueller (60) studied physics in Stuttgart, joining Siemens Healthineers immediately after graduation in 1983 as part of the first large intake of employees for the newly opened MRI research center. Mueller's original plan was to stay in this sector until he had completed his doctorate, and then move on to the pharmaceuticals area. But developing MRI proved to be so exciting that Mueller has remained true to this technology for more than three decades. After initially working on general system development tasks, from 1991 onwards he spent 12 years developing neurofunctional imaging (fMRI, functional Magnetic Resonance Imaging), a technique that makes it possible to map brain activity. Since 2005, he has been working on the further development of cardiovascular MRI, involving compressed sensing. From 2016 onwards, he has been responsible for innovation and technology management at MR. Mueller has registered 46 inventions that are protected by 50 patents in 40 patent families.

Michaela Schmidt (48) trained as a medical radiology technician at the University Hospital in Erlangen. Later on, she worked at the University Hospital in Zurich as a research assistant in the MRI area. She returned to Erlangen in 1999 to work for Siemens Healthineers MR. She has remained there to this day, working as an application developer in R&D projects for cardiovascular imaging. Schmidt's focus lies on developing workflows for MRI scans, collaborating with clinical partners, and evaluating and enhancing image quality. Schmidt has registered 24 inventions that are protected by 26 patents in 22 patens families.

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Dr. Michael Zenge (41) studied electrical engineering in Aachen, specialized in signal processing, and gained his doctorate in Essen with a thesis on angiography. Honored for this thesis with the "Young Investigator Award" from Siemens, he started his career at Siemens Healthineers at the end of 2006. Zenge worked on advance development topics in cardio imaging as part of Edgar Mueller's team, and immediately recognized the potential for using compressed sensing in MRI. On completing the research project, Zenge took up a three-year position as collaboration manager at the University of New York, working with radiologists and engineers who partner with Siemens