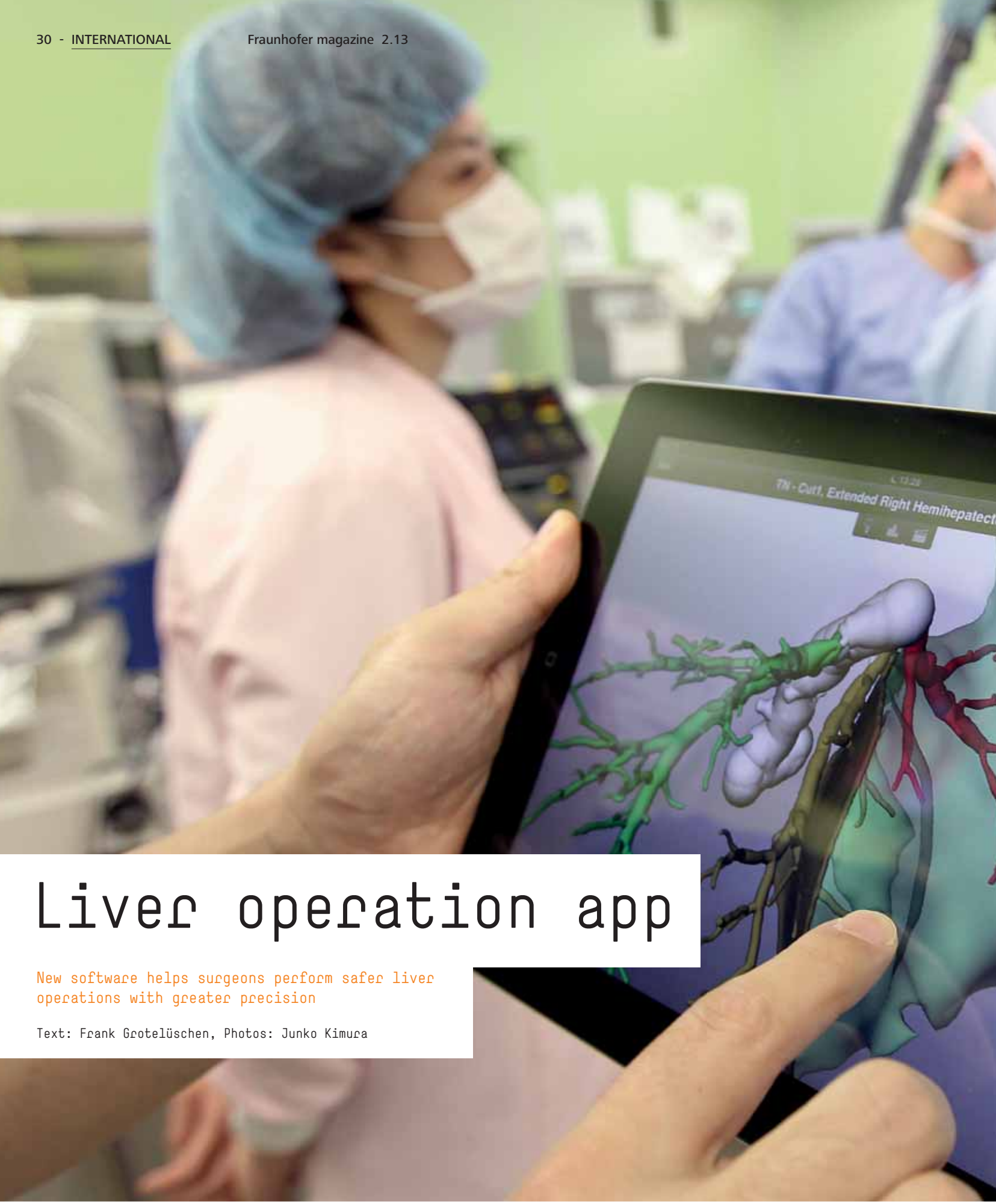
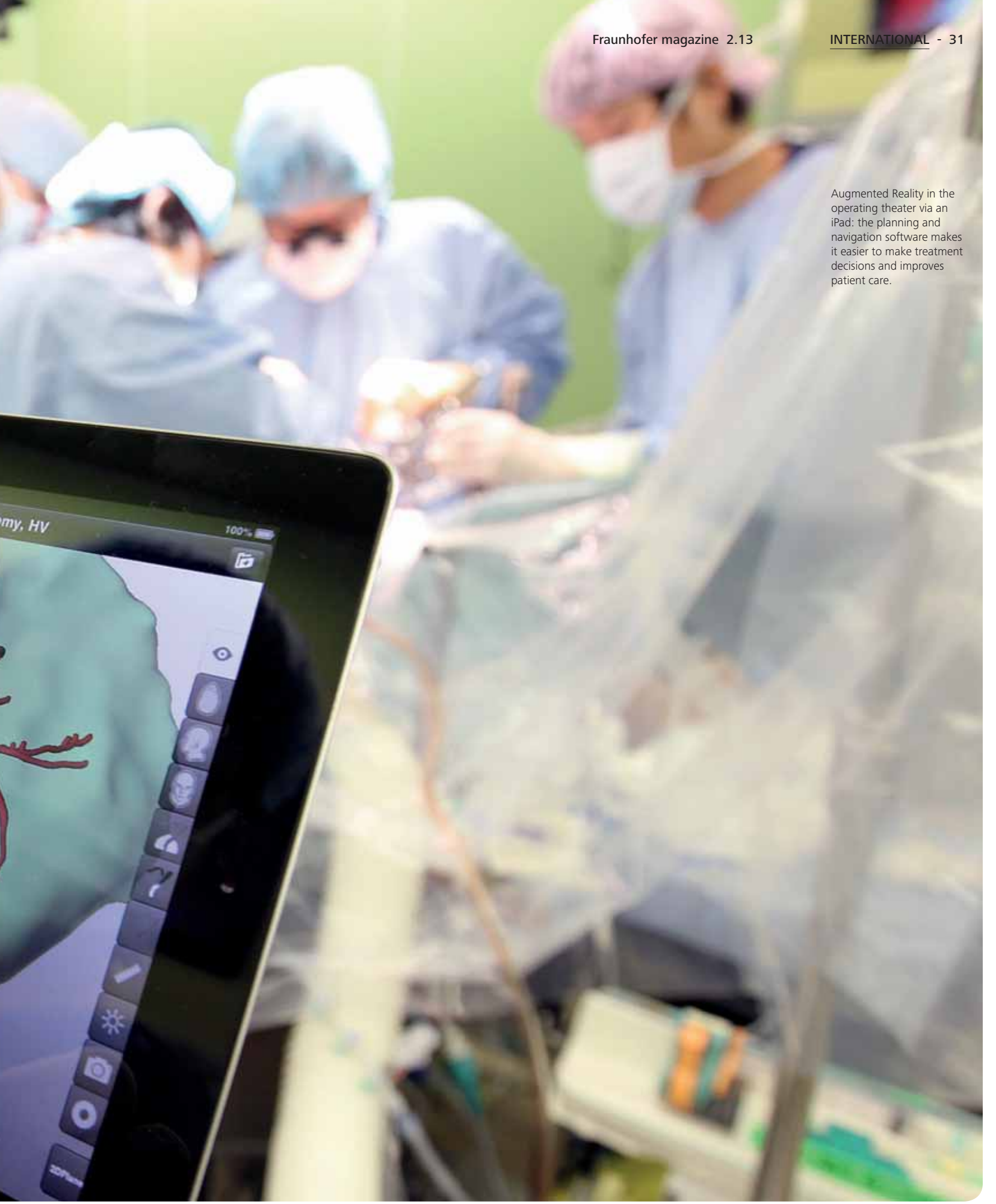


Liver operation app

New software helps surgeons perform safer liver operations with greater precision

Text: Frank Grotelüschen, Photos: Junko Kimura



Augmented Reality in the operating theater via an iPad: the planning and navigation software makes it easier to make treatment decisions and improves patient care.

The operation demands extreme concentration and utmost care from the team of surgeons, who are attempting to remove a dangerous liver tumor from their patient. Since the liver is a complex organ, operations are difficult and can last several hours. "There are countless blood vessels running through the liver that supply the organ with 1.5 liters of blood every minute," says Andrea Schenk, head of liver research at the Fraunhofer Institute for Medical Image Computing MEVIS in Bremen. "It is vital that surgeons know exactly where the blood vessels are located when they are operating, as one false incision could result in the patient losing a great deal of blood, with potentially serious consequences."

New technology developed at MEVIS will help minimize this risk. The key feature of this new tool is that it is based on an object that many of us use every day for surfing the web, reading or to entertain ourselves – the iPad. The initial idea came from Itaru Endo and Ryusei Matsuyama, two surgeons at the Yokohama City University School of Medicine in Japan who have been working with software developed in Bremen. The software uses computer tomography images to calculate the precise location of blood vessels running through each patient's liver in 3D. This helps the surgeons to plan each operation more precisely, and allows them to gauge the exact location of necessary incisions in each individual case.

Planning operations using an iPad instead of paper

"We've been using MEVIS software since 2003," explains Endo, "and it has helped to significantly reduce patients' blood loss in over 60 surgeries." However, the Japanese surgeons had requested one improvement. In order to view the images generated by the MEVIS software during an operation, the surgeons had to print the pictures out and hang them on the walls of the operating theater. But since not all the information including the 3D data the surgeons needed could be printed out, they were forced to make additional mental notes.

So Endo and Matsuyama asked the institute in Bremen if it would be possible to transfer the planning data onto an iPad, so that they could access them during each operation. Fraunhofer was immediately taken with the idea, and expressed a keen interest in pursuing further collaboration. After some initial preparatory work, Alexander Köhn, a computer scientist at MEVIS, packed his bags and traveled to Japan for three months to develop the software in collaboration with the surgeons.

The experts quickly realized the ipad's full extent of the iPad's potential. Not only can it display all the necessary planning data during the operation, it also helps to extend reality and offers a host of other useful benefits. "Augmented reality" allows the surgeons to visualize the entire system of blood vessels inside the liver using the tablet. Köhn demonstrates how this works using a model of a liver on his desk. The scientist holds the iPad over the model and switches on the camera. "I'm effectively looking through the iPad and seeing the liver underneath," he says, describing the effect. "Now I can superimpose the virtual data provided by our planning software, which lets me see the blood vessels inside the liver!"

The vessels resemble trees in winter, with thick stems branching out into innumerable thinner branches that become finer and finer. To help distinguish between the veins and arteries, the different vascular systems are depicted in different colors. The surgeon can use the iPad to "project" this delicate pattern onto the liver, and then precisely mark the position of the vessels onto the organ using a special pen. This offers the surgeons the significant advantage of making their incisions in exactly the right places.

Köhn continues by demonstrating another aspect of the software, namely its "eraser" function. Once a surgeon has cut through particular blood vessels, there is no longer any need to see them as part of the images shown on the iPad. These obsolete blood vessels are simply obstructive, and could block the view of other important vessels in the surrounding tissue. This problem has been solved by giving surgeons the option to "erase" the blood vessels on the tablet. Köhn simply has to do is swipe his finger over the branch of blood vessels on the touchscreen for that branch to disappear.

The app has other tools that are helpful when complications arise, as is often the case with liver operations. Sometimes tumors are found to be larger than anticipated, and surgeons have to change their plans unexpectedly. This occasionally makes it advisable to cut away more branches of blood vessels than originally intended, although doing so increases the risk of causing extensive damage to the patient's liver. The app helps surgeons to weigh up these risks. Alexander Köhn taps the blood vessel in question with his finger on the screen. A split-second later, the iPad shows a cloud-like shape appear at the end of the vessel; this is the liver volume supplied by the vascular branch that would cease to function if the blood vessel were cut. "It's 37 milliliters in this case," says Köhn. "Now the surgeon can decide whether the remaining volume is large enough for the patient to make it through safely."

It took the MEVIS computer specialist several weeks to write the software in Japan and to adjust it to suit the surgeons' requirements. Then the first version was ready. "The surgeons were impressed, and could hardly wait to try out the new software in the operating theater," says Köhn. It wasn't long before the new Fraunhofer app made its surgical debut on an iPad covered with sterile plastic developed specially for medical purposes.

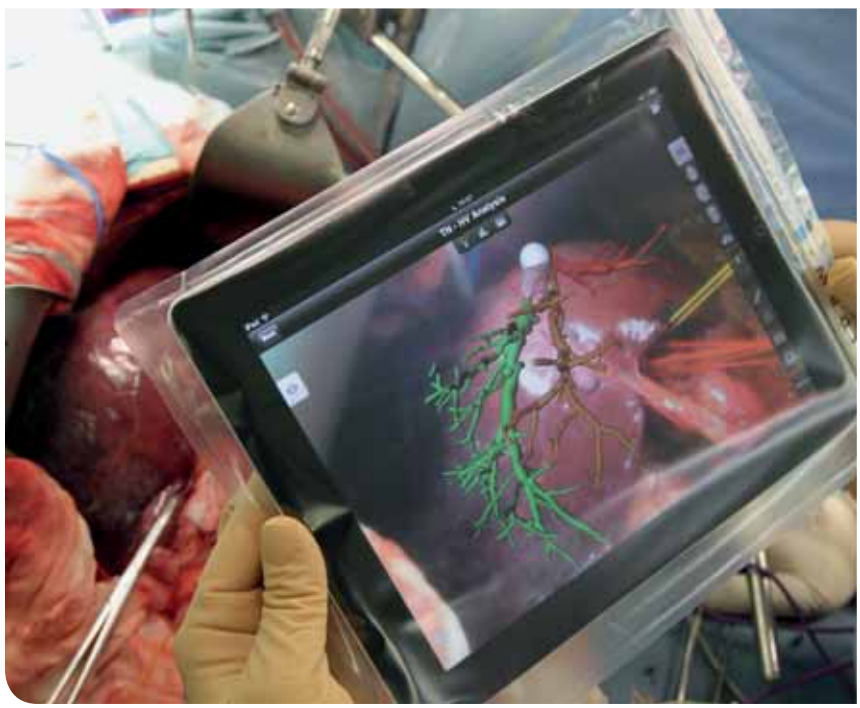
The surgeons were quickly able to align the real and virtual images of the liver on the iPad display and show all the blood vessels. "When Dr. Endo saw it, he exclaimed 'sugoi', which means 'super'," remembers Köhn. "The new software made a real difference straightaway, in the very first operation." The surgeons were able to precisely mark the location of the blood vessels on the surface of the liver. This meant they knew the exact locations of the vital vessels that could under no circumstance be severed accidentally and could guide their scalpels safely.

"The new technology could further reduce the amount of blood lost during surgery," hopes Itaru Endo. "It would result in fewer complications, and shorten the amount of time spent in hospital after an operation." Initial tests are now to be followed by clinical studies, including in Germany. "These studies are to provide quantative confirmation of the value our new tool adds to surgical practice," explains Andrea Schenk.

And this is only the beginning. MEVIS experts are already thinking about other possible uses for the iPad beyond the operating theater, and are considering how iPads could be used throughout the entire hospital. When doctors visit patients on their rounds, a chip at each bedside could automatically transfer relevant medical data to the doctor's tablet. "This could be used, for example, to show patients their own unique liver images and explain to them exactly what will happen during the operation," says Schenk. "This would be very helpful for both doctors and patients." ■

In order to be able to view planning data during the operation, surgeons had to print out images and hang them on the walls of the operating theater.

Dr. Ryusei Matsuyama using the iPad whilst performing a liver operation at Yokohama City University Hospital.



Augmented Reality: the liver is shown via the iPad's camera, and virtual data from the planning software is superimposed over the image so that the blood vessels become visible.