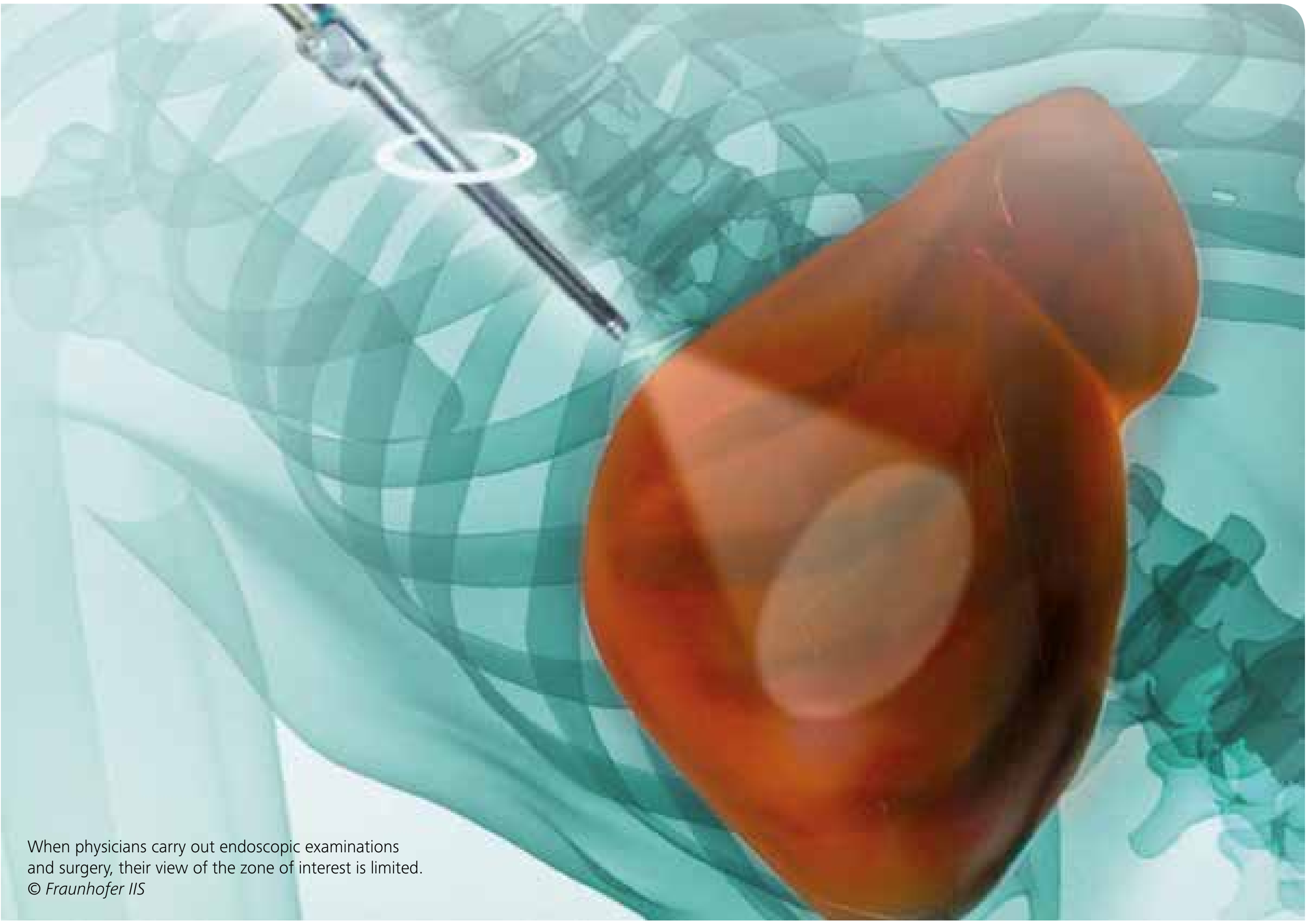

When physicians carry out endoscopic examinations and surgery, their view of the zone of interest is limited.

Endoscopy with a panoramic view

When doctors use an endoscope to examine or operate on the bladder wall, they can only see a tiny section of the organ at any one time – as if they were peering through a keyhole. A new software solution that provides a wider, panoramic view may be available in a few years' time to support endoscopic procedures.

Text: Janine van Ackeren

Painful urination or traces of blood in the urine are symptoms that could indicate anything from cystitis to a malignant tumor of the bladder. The best way to be sure is to undergo an endoscopic examination. The physician introduces the endoscope into the patient's bladder through the urethra and looks at the images captured by the camera to check for abnormal changes in the examined tissue. While such minimally invasive procedures are virtually painless for the patient, they pose certain problems for the physician, whose view of the bladder wall is limited to the tiny area of tissue on which the camera lens is focused at any particular instant in time. To examine a wider area of surrounding tissue, the tip of the endoscope has to be repeatedly repositioned to obtain more imaging data. Even so, this series of isolated images doesn't provide a complete picture of the bladder wall, and the physician cannot be sure that he/she has carried out a thorough examination.

Widening the keyhole perspective to a panoramic view

Future endoscopic cameras will be able to provide a panoramic view. "The Endorama software that our researchers have developed merges the separate images into a single picture – in close to real time," reports Dr. Thomas Wittenberg, chief scientific officer at the Fraunhofer Institute for Integrated Circuits IIS. In this way, the physician has a complete view of all examined areas of the bladder at a single glance. The software displays the most recently recorded image in the center of the screen. If there are any blank spaces in the panoramic view, this informs the physician that this area of the bladder wall has not yet been examined. Endorama also simplifies the preparation of case records. Instead of inserting individual images in the patient's medical file, the physician can attach a panoramic image that contains all of the results of the medical examination and, moreover, proves that every area of the bladder was examined.

Most smartphone cameras these days are capable of producing panoramic photos. To do this, a software program looks for distinctive structural features in each frame and uses them as reference points for joining consecutive images to create the full picture. It is more difficult to produce a panoramic view from endoscopic images. The video camera at the tip of the endoscope captures around 20 to 25 overlapping frames per second, but the image quality is comparatively poor. The images usually suffer from optical distortion, they have a low resolution, and their contrast is marred by uneven lighting. Moreover, the structural features of the bladder are relatively indistinct, which makes it difficult to find reliable reference points that could be used to align the overlapping images.

Endorama - Enhanced Endoscopy Vision

Endorama solves all of these problems. The software starts by applying algorithms to correct for optical distortion and eliminate the shadow effects caused by uneven lighting. Then a number of different computing processes are used to join the images. While one process looks for suitable anatomical features that could be used as reference points, such as the blood vessels in the bladder wall, another process uses this information to align the images. The mathematical models on which these processes are based were designed to take into account the complex geometry of the bladder.

Endorama has already passed initial tests with flying colors. In the first software review, the researchers used a phantom configuration consisting of a hollow plastic ball measuring ten centimeters in diameter onto which the vascular structure of the bladder was imprinted on the inner surface. The researchers also used their algorithms to assemble a panoramic view from video sequences recorded during conventional cystoscopy examinations. Wittenberg estimates that Endorama could be launched as a commercial product within the next two or three years.

The same method can be applied when examining other human body cavities. For instance, in the case of a suspected tumor in the pituitary gland, the physician performs a biopsy by inserting an endoscope through the nose into the sinus cavity and extracting a bone sample. The resulting hole allows the endoscope to penetrate the brain, creating a passage through which surgical instruments can be introduced to remove the tumor. This is an extremely delicate operation, because the surgeon has to be very careful not to damage any nerves or compromise healthy brain tissue. Conventional techniques using a rigid endoscope provide no more than a partial view of the nasal cavity, as in bladder inspections. Here too, Endorama provides a wider view. "But such neurosurgical applications are still at the development stage," comments Wittenberg.

Esophageal endoscopy: no longer limited to a tunnel view

Another of the researchers' objectives is to facilitate endoscopic examinations of the digestive system. To do so, they are working on a software solution that they call TubeStitching. The problem is similar to that encountered by trains when passing through a tunnel. "When the train enters a tunnel, the driver's range of vision decreases exponentially as a function of the light intensity. But a bright ring of light illuminates the tunnel wall within a defined distance of the train's headlamps, providing perfect lighting conditions in this section of the tunnel," explains Wittenberg.

A similar principle applies during endoscopic examinations of the esophagus. In the ideal case, the light source illuminates ring-shaped sections of the esophageal wall. As the physician gradually withdraws the endoscope, successive rings become visible. The TubeStitching program selects images of the well-lit segments and "stitches" them together to produce a two-dimensional picture of the length of esophagus that has been examined. The system could be ready for commercialization within about two or three years.

The researchers also intend to use the new technique in industrial applications. "We envisage using it to examine complex hollow spaces in an engineering context, for instance in cars or aircraft," Wittenberg tells us. Automated procedures for inspecting cylindrical openings such as brake cylinders using a rigid endoscope have been in use for many years. But winding cavities are quite a different matter. It is for this type of situation that the scientists want to develop solutions. "We are already engaged in discussions about this with industrial customers," reveals Wittenberg, who originally worked in the field of technical endoscopy. ■