Automation in medical technology is no longer an alien concept. Increasing cost pressures and staff shortages call for new techniques to be used to improve operational efficiencies.

Showing Robot Assistants the Way

Assistance systems and surgical robots are being used increasingly in a variety of medical applications. Reliable displacement measurement is paramount for these devices. The Micro-Epsilon solution using draw-wire sensors is safe and simple to use. In series, for example, these sensors are employed in an assistance system to minimise invasive surgical interventions. Durability, reliability and compactness, as well as high accuracy and a modest price are the basic requirements for measuring systems in medical technology. Draw-wire sensors in particular meet these needs to a high degree.

In minimal invasive surgery, the surgeon normally works with two different tools, a holding instrument and a cutting tool. These tools are inserted into the body through small incisions in the abdominal wall, in order, for example, to remove the gall bladder. Since no direct view of the operative field is possible as in open surgery, it is necessary to work with a camera image on a reference monitor. Up to now, the endoscope held by a second surgeon must not be shaken – even during an operation that lasts several hours.

This procedure had a number of disadvantages. On the one hand, the communication problems arising from this division of responsibilities between operating and viewing, and on the other hand, the fact that humans are not designed for lengthy, static holding tasks. This resulted in an image that was unstable and that wobbled. In addition, there was an increasing shortage of surgeons in many hospitals, above all in small ones.

1 The Soloassist robot assistant aids physicians in minimally invasive surgery

These disadvantages are now compensated for by the Soloassist from Aktormed, based in Barbing near Regensburg. A second surgeon is no longer needed at the operating table. The endoscope is clamped into the Soloassist (**Figure 1**) and is now moved directly and easily by the surgeon using a joystick.

Thanks to its universal construction, the Soloassist can turn the endoscope through 360° around the insertion point and, at the same time, pivot it up to 90°, so that the surgeon can view the entire abdominal cavity with ease. It can be used in visceral (abdominal) surgery, as well as in urology and gynaecology. The surgeon can also operate comfortably alone with the Soloassist. As before, the surgeon is backed up by a surgical nurse.

Wire sensors work like tape measures

Technically speaking, the Soloassist is a hydraulically-driven articulated robot, specifically designed to perform medical tasks. It is mechanically controlled by a dual electronics system. A PC calculates the necessary movements, whilst a second electronics system ensures safety. Parts of the device must and can be sterilized. This is carried out in an autoclave at 134 °C.

Three wireSENSOR MK30 draw-wire sensors from Micro-Epsilon are used to measure the Soloassist's movements. With these sensors, it is possible to log the change in the angle of the axes and to process freely. The active camera work must display X-ray images with as few shadows as possible – therefore no encoder or potentiometer can be used. The size of the draw-wire sensors is ideal and ensures the required accuracy. The sensors can be easily mounted and adjusted. Only the wire of the sensor is inside the robot arm. The sensors themselves are located under the table and so have hardly any influence on the X-ray images.

In the last example, wire sensors work like a tape measure (**Figure 2**), albeit one in which the displace-

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With the non-leading hand, the surgeon controls the movements of the system with the wireSENSOR units, accurate to a few millimetre

ment or distance information cannot be read with the naked eye, but is output as an electrical signal.Therefore, besides the housing, the essential elements of a draw-wire sensor are the spring, the drum, the measuring wire and a protractor as a sensor element. The measuring wire is attached to the device being measured and is wound or unwound by a movement of the drum. In this way, the linear motion is converted into a rotational movement, which is then measured by an angle sensor.

If the measuring distance is reduced, the measuring wire is automatically rolled back on to the drum. The necessary force is provided by a pre-tensioned mainspring. The cable tension is so great that when the device is installed horizontally, the wire sag is also minimized and so the result is hardly affected.

In principle, all commercially available and suitably sized angle sensors can be used as sensor elements. This allows a large variety of different output signals. From analogue signals (e.g. potentiometric, 4 to 20 mA, 0 to 10 V) to incremental signals (such as TTL) and fieldbuses (CANOpen, ProfiBus), nearly all common interfaces can be achieved.

Wire sensors for medical applications typically use multi-filament spiral wire or hybrid potentiometers. These provide the necessary performance for many applications at an affordable price. The difference between the two types is in their respective service life. While draw-wire sensors with wire potentiometers are limited to approximately 200,000 cycles, up to one million cycles can be achieved using hybrid potentiometers.

Encoder-based sensor elements can be relied upon when higher demands are placed on service life and/or accuracy, as is the case with CT tables. Here, a linearity of up to ± 0.01 percent of the measurement range and a considerably longer service life can be achieved. In addition, the displacement sensors can be controlled via digital interfaces, which are also increasingly finding their way into the medical technology field.

Hybrid potentiometers have a long service time

For many years, Micro-Epsilon has been using injection-moulded plastic enclosures in medical technology, in contrast to the metal housings that are otherwise standard in industrial applications. This guarantees not only the smallest possible size, but also low costs with large volumes. This means that full use can be made of the inherent economies of scale that these sensors already offer.

By combining different sensor elements and measurement ranges with the available enclosure options, an ideal draw-wire sensor can be provided for virtually any OEM application. Draw-wire sensors are therefore used in series in a variety of different applications.

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2 An insight view into the draw-wire sensors' structure. The measuring wire is precisely rolled onto the drum