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User interfaces for an integrated OR

A practice-oriented approach has been taken to this topic by the steute business unit Meditec and CITEC (University of Bielefeld) in a project of the "it´s OWL" excellence cluster.

In the OR, increasing numbers of medical devices are being used – for example because surgical procedures are supported by simultaneous imaging techniques. For the surgeon this means switching frequently between different devices and their individual controls. This is complex and requires concentration, often limiting the usability of the devices. At the very least, intuitive handling becomes increasingly difficult. This is one of the reasons why the integrated OR is a concept currently undergoing intensive study by leading manufacturers of medical devices, as well as the suppliers and developers of their corresponding control devices.

Cooperation between research and industry

At the human-machine interface level, integration leads to the surgeon being able to operate several devices with one and the same control.

Voice, gesturing, touch, eye movements? State-of-the-art human-machine interfaces come with many different options. But which ones are suitable for the OR, i.e. for medical devices? Especially considering the increasing numbers of devices surgeons have to operate?

This "interoperability" is the goal of several projects involving the steute business unit Meditec. In one current project, organised by the excellence cluster "Intelligent technical systems – it´s OWL", steute is cooperating with CITEC from the University of Bielefeld. The abbreviation of this excellence cluster stands for "Cognitive Interaction Technology", and it has around 260 top-level researchers working in the field of robotics and human-machine interaction. Their goal is to develop machines which are intuitively operable, which interact with human beings in a natural manner, and which are able to adapt to changing situations.

Demonstrator for the interoperable OR.

Multimodal user interfaces for the OR

CITEC has comprehensive expertise in the study and evaluation of human-machine interfaces and attaches great importance to research findings which help in practice.

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This was also the principle underlying the it´s OWL project"OPtimal – Nutzerschnittstellen für den OP multimodal und adaptiv gestalten" (multimodal and adaptive design of ideal user interfaces for the OR). This project centres around the question of whether and how established foot control can be complemented by innovative forms of interaction such as voice control or gesturing.

Voice control to complement or replace foot control?

In a first step, the CITEC researchers made a thorough appraisal of OR work processes and the requirements made of conventionally used interfaces – with methods including market research, observation in the working OR, and interviews with surgeons and surgical teams.

Typical user interface for medical devices.

Foot control is established throughout the surgical field – one key finding from the first phase of the project – and held in high regard by users. Of the alternatives available, two could be ruled out at this early stage of the project: a gesture-based interface is problematic because the surgeon rarely has his hands free during an operation, while an interface based on eye movements (technically possible) puts an additional strain on surgeons, who then have to watch out during an operation where they look. In contrast, voice control appears to be both viable and realistic for both the practitioners questioned and the scientists. The next phases of the project therefore focused on foot control and voice control as forms of human-machine interaction.

Prototype for simulated surgery

On the basis of these findings, a prototype was developed which could simulate four cases of spondylodesis (stiffening of the spine) surgery. The (virtual) device performing the surgery required two-handed operation (using a gaming controller) in order to simulate the surgeon having both hands occupied. Three different techniques could be tried out when using the device: universal foot control, voice control, and combined multimodal foot and voice control.

Evaluation with 60 test persons

In a test involving sixty participants, CITEC evaluated these three techniques for setting and controlling the device in terms of their impact on user performance, on cognitive stress and on subjective assessment of the overall system. Subjective assessment of the interface was also investigated. Each participant performed the same operation several times in order to allow for "learning by doing".

CITEC also has comprehensive expertise regarding the analysis of such results. Here, work included the success rate of the surgery following the various attempts, the time taken to complete each task, the

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number of commands required, and the error ratio. Subjective assessment of usability and user experience were recorded using various questionnaires.

Prototype for different ways of controlling equipment during spinal surgery. Here foot control is being used.

Foot for functions, voice for device selection

The results of the project revealed a clear participant preference for unambiguous "job sharing" between foot and voice control. The test persons predominantly (and increasingly as the test progressed, in other words as their experience grew) use foot controls to set functions and trigger commands. This has been the typical job performed in the OR by foot controls to date, one which here could be confirmed as an appropriate or even ideal choice. In contrast, when selecting a device – which device should the foot control operate next? – Voice control proved to be the most practical method. In applications and demonstrators already realised in the integrated OR, this task has to date usually been performed by touch-screens.

This job sharing of "foot for functions, voice for device selection" was subjectively preferred by the test persons, and also proved to be the best choice objectively. One important factor which should not be underestimated here is the intuitive operability offering perfect ergonomic comfort, with up to 50% of avoidable, treatment-related health impairments being attributable to "suboptimal" human-machine interfaces on medical devices. In this project a clear preference emerged for innovative interfaces in the OR, one which steute Meditec will continue to pursue in the future.

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