"Actions of Interest" in Surgical Simulators

Inge Hinterwaldner

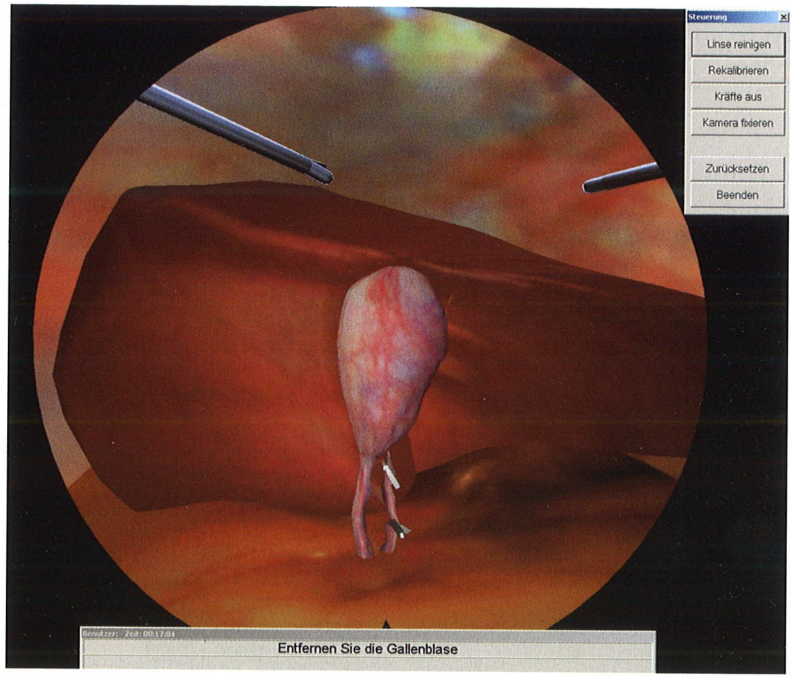
Beyond anatomical models used to study a standardized build, other types of plastic phantoms have been applied in medical training for some time now, specifically designed for practicing diagnosis, emergency treatment and surgery. In most cases these training aids are just "truncated" bodies. However, they are neither broken nor mutilated. The line that divides the part from an imaginary whole only very rarely marks the area to be operated on. The main focus of interest is somewhere on the central area of the synthetic fragment. The missing part is not lost but seems to be negligible for the task at hand. As these tools are made of plastic, one can basically do with them everything this material allows. However, we have to ask ourselves whether, with these analogous artifacts, everything that is present-at-hand is at the same time ready in a useful or an intended way. On closer examination we will often have to answer this question in the negative and distinguish between the functional core and the periphery it is embedded in. Sometimes, the central parts of a manikin can be clearly recognized by the different items that can be inserted into these areas to examine various "cases" or to exchange the variants already "used". Consequently, the extent of the intended scope for action does not necessarily at the same time mark the limits of the given form. The thigh stump of a birth simulator [see figure 1, top left], for instance, bears no resemblance to a real thigh with its bones, blood vessels, nerves and the like. Why should it? These features can obviously be dispensed with in the kind of surgical training the tool is used for. The simulator does not need to be complete in the generally accepted sense of the word but has to fulfill specific requirements in terms of handling.

A similar situation is to be expected in the field of computer-based simulators. In numerous digital surgical simulators, there is little more than the two organs, let's say liver and gallbladder, which form a unit for an operation, for example in the training program "VSOne Cho" for laparoscopic cholecystectomy, which was developed at the Forschungszentrum Karlsruhe.[1] Here, in our search for the limits of operability, we are more interested in the simulated image than in the appearance of the simulator. In real-life minimally invasive surgery, surgeon and assistants orient themselves through the images transmitted by an endoscopic video camera in the abdomen. Analogously, when practicing on a simulator the trainee looks at a screen and not at the patient. The trainee sees the model of the insides of a body, which is calculated in real time. More precisely, he or she sees what a synthetic camera with a 30-degree lens sees in a simulated body, which seems to be prepared for surgery, at least in so far as it was inflated to offer room for an operation or insight in the first place.

The circular shape of the calculated camera image is completely taken up by the interior view. As a rule, the scenario can be seen from only one viewpoint and, as in real surgery, it is not possible to see the entire situation at the same time. However, the incompleteness of the artifact is probably even more differentiated than the image suggested by what is presented to the eye. The boundaries are not necessarily visible at first sight but become clear only in the course of interaction. If one cuts, for instance, into the horizontal tissue in figures 2 and 3, a hexagonal hole leading into emptiness emerges. What is thought to be tissue turns out to be a two-dimensional area, which was inserted to round off the visual effect. The large hexagon apparently belongs to a category of signs, which are not meant to represent something in the body. It rather has to be read as a symbol. This visual

1 See Uwe Kühnapfel, Hüseyin K. Çakmak, Heiko Maaß, "Endoscopic Surgery Training Using Virtual Reality and Deformable Tissue Simulation," in: *Computers & Graphics*, VOL. 24, NO. 5, 2000, PP. 671-682.

Fig. 1. Medical manikins, 2005, collage, © Inge Hinterwaldner



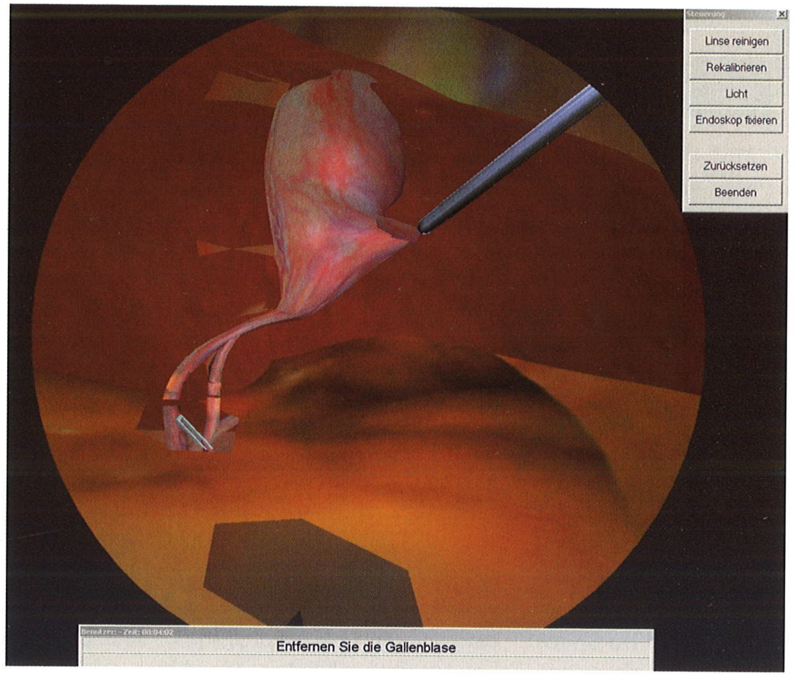


Fig. 2, 3. Institut für Angewandte Informatik (IAI) / Forschungszentrum Karlsruhe, select-IT's simulator "VSOne Cho" developed at the Forschungszentrum Karlsruhe, 2003, screenshots, © Institut für Angewandte Informatik (IAI)/ Forschungszentrum Karlsruhe ■ This scenery shows a brown liver in the background, a gallbladder, a bile duct, an artery with clips, and a fat tissue as well as surgical instruments.

solution shows that we have departed from the accumulation of elastodynamically deformable objects, which would be relevant for the given operation and is based on "physics". A transition to a peripheral area has taken place, which is not sensitive for more subtle interaction: The hole points to its imperviousness to action.

We would like to give another example. It is an example that cannot be interpreted as a didactic measure and cannot be classified as "transgression failure" and therefore cannot be explained in terms of mere local distance. In some simulators,[2] only what is thought to be essential (the end-effector of a surgical instrument, for example, but not its shaft) is equipped with a collision-detection system and a force-feedback component. This has "some advantages in computation," but it allows the simulated organs to intersect with the shaft without resistance. Also, one can apply the instrument to operate in some places as if it had no shaft, places in which this would not be possible in reality. In our example, too, we find deviations from what is expected. This simulation was deliberately programmed so that the liver cannot be cut, and it is possible to fix clips only on the thin tubes.

Analogue as well as digital simulators are designed for a specific and limited scope of application. The term "region of interest" (ROI), which is frequently used in scientific imaging, would be appropriate only if the underlying definition of "region" is not a strict spatial one. The example of the "penetrable" shaft suggests that it is better to focus on the scope for action. The term "action of interest" is probably more accurate, although it has already been used in jurisprudence and psychology, where it has a completely different connotation. In the case of procedural trainers the degree of differentiation of the modeling is adjusted to the "actions of interest" and vice versa. We therefore prefer an approach that refrains from using "limitation" as a purely quantitative measure, but rather assesses the design of simulators in view of what is practiced on them.

We must analyze critically to what extent it is justified to consider state-of-the-art simulators starting from this premise. Would that not deny that the applications are still immature, inadequate and at an early stage of development? Here, an external and therefore probably weak argument can be brought to bear: After all, these trainers have been put on the market in the present form, they have already been practiced, a certain usefulness has been attributed to them. In addition, it has to be mentioned that the tools are not "only" deficient. On the contrary, in other respects they are "overzealous" compared to a real-operation scenario. The handles of instruments that are dropped, for instance, can vibrate, warning or instructing texts appear on the screen, illumination is variable and sometimes images are generated that go beyond the experience of a practitioner.

It can therefore be said that in many respects a simulated operation scenario based on computation does not coincide with the real-life situation. Instead they must be thought of as different domains, which overlap only partially. The degree of fidelity is the wrong criterion with which to assess simulators, as they are hybrids of anatomical imitation and ideal procedures. Simulators embody implemented rules for action (such as the Berlin key[3]). This close entanglement will have to be taken into consideration as soon as the focus in "virtual prototyping" shifts to future-oriented modeling.[4]

2 It should be emphasized that this is not valid for "VSOne Cho".

3 See Bruno Latour, "The Berlin Key or How to Do Words with Things," in: *Matter, Materiality and Modern Culture*, Paul M. Graves-Brown (ed.), Routledge, London and New York, 2000, pp. 10-21.

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