The Virtual Liver Surgery Planner - - Results by a Novel Human Machine Interface

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History of Human Machine Interfaces:
For about hundred years the human machine interface did not change -- there was a keyboard for typing aand a display device for visualization of the typed text (first a sheet of paper, later a Computer screeen).
In the 80's the "Computer Mouse" was invented, followed soon by graphical users interfaces. An American Company covinced the world, that the magic stuff about computing is "point & click" or "drag & drop". People followed this track. Never the 2D of the Computer screen was left.

Problem:
Today's imaging modalities like 3D Ultrasound, Spiral Computed Tomography (S-CT) or Magnetic Resonance Imaging produce data within the amount of the human genome. More than 1000 images per study represent not an exception. Therefore conventional slice by slice reporting seems to be outdated.
An interdisciplinary, international team designed a new system for plannnig liver surgery, based on S-CT imaging -- "The Virtual Liver Surgery Planner" (VLSP), which exploits techiques from Virtual Reality.

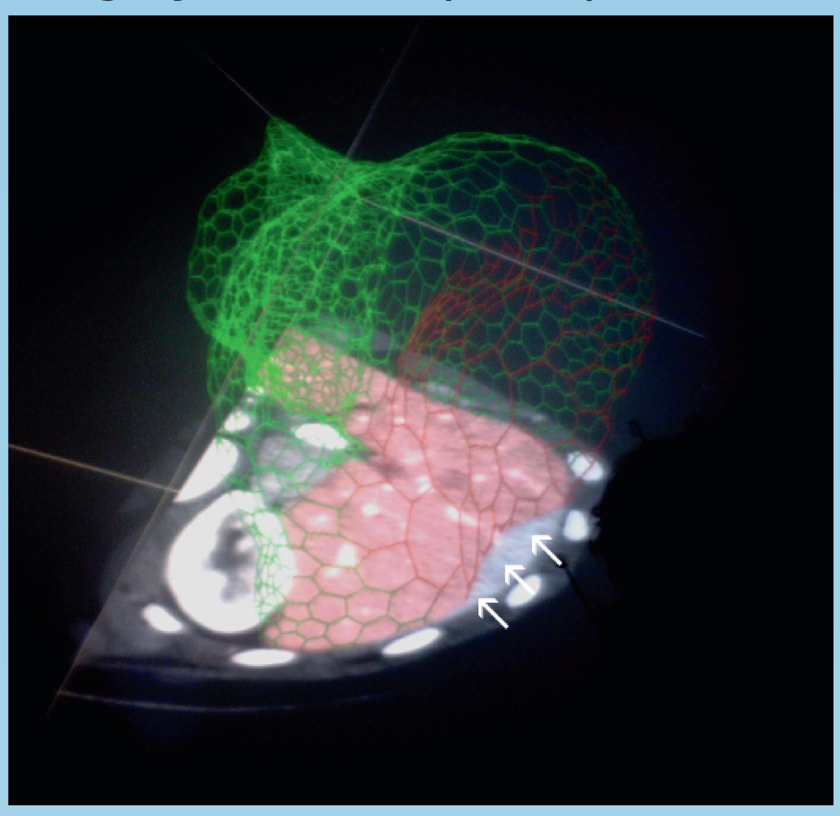

Fig.1: Artificially deformed liver -- deformation is marked by arrows.

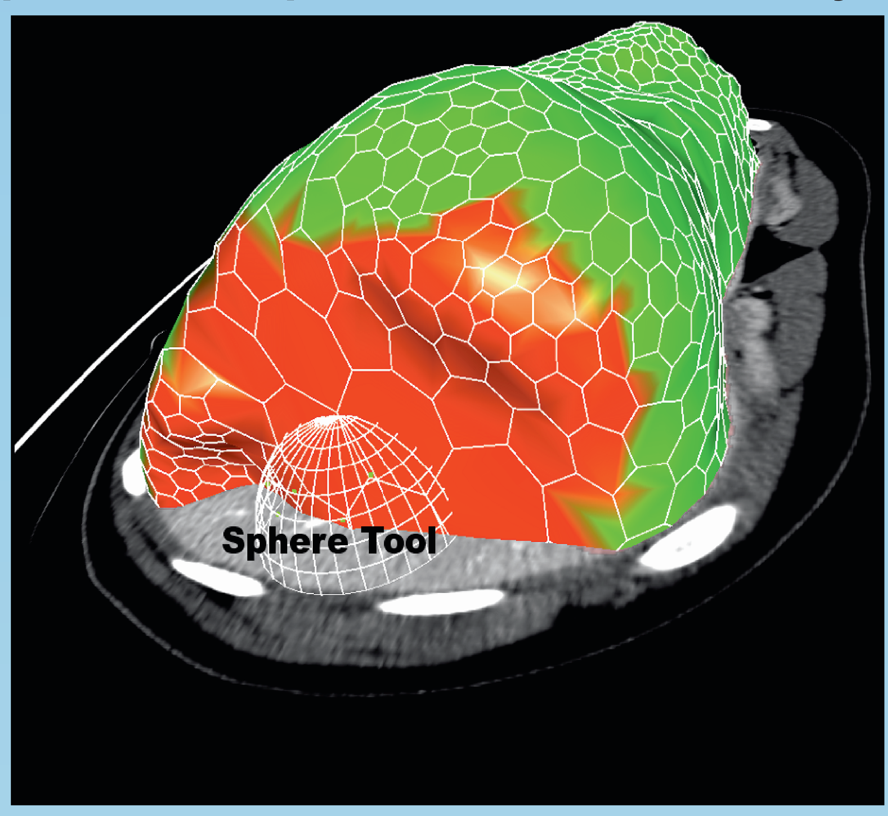

Fig.2: Sphere tool in "Action" -- the sphere tool represents a device, which allows to select a particular area of the liver surface (marked in red) and afterwards to "push" or "pull" the selected liver contour as long as it fits the desired one. This procedure allows fast and easy 3D editing.

Scene #	Induced Error
1	15.2%
2	6.7%
3	9.2%
4	4.1%
5	64.2%
6	8.4%
7	38.8%

Tab.1: Volume error produced artificially for evaluation of 3D editing tools.

System Evaluation:
The VLSPS system was evaluated in different ways. First, there was interest, if there is any advantage of the 3D editing tools (see neighbouring poster). Therefore from seven S–CT scenes the liver surface was segmented and a local deformation produced artificially (Fig.1). The original liver volume as well as the volume of the deformed liver were known. Therefore the volume error, as produced by the deformation, was known (Table 1).

After wards three observers edited these seven scenes with the help of the 3D tools and the relative volume deviation of the edited liver volume from the original one was calculated again (Fig.2). As it is depicted in Fig.3, after an average of only 10.8min the final deviation was well below 4%.

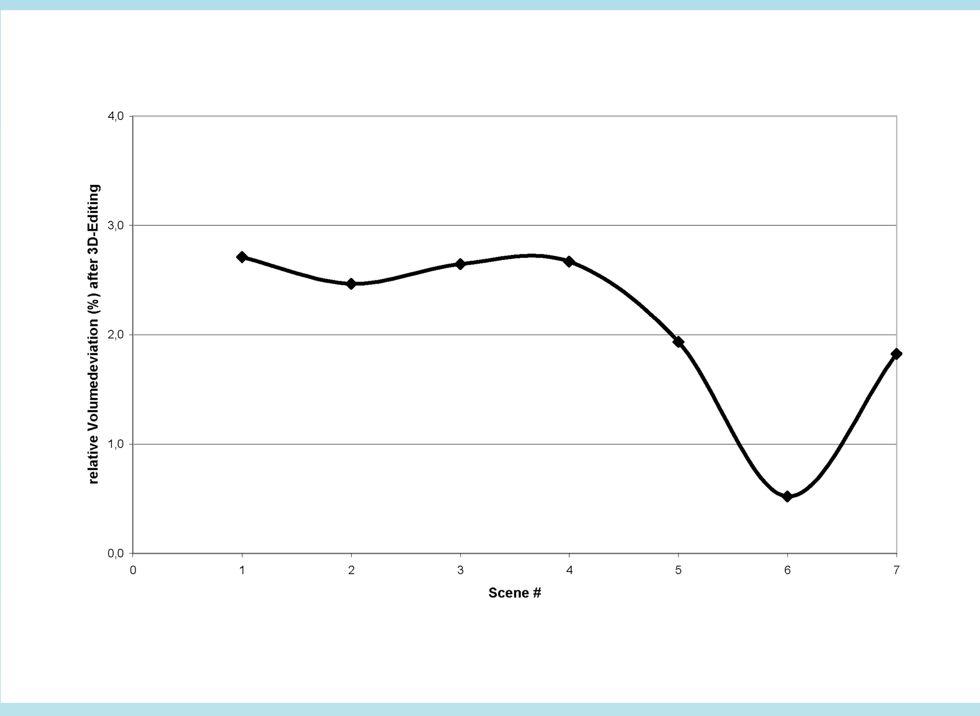

Fig.3: Chart displaying the final volume deviation after 3D – Editing of seven scenes by 3 operators. As it can be seen the .nal deviation is well below 4%. An average time for 3D – Editing of only 10.8min was necessary.

Another setting of scenes was targeted to the assessment of the accuracy of the augmented reality system. Therefore 13 scenes were prepared in the following way: a patient's liver surface was segmented from a Spiral – CT scan and different shaped and sized geometrical bodies "transplanted" (one or more) – these bodies should simulate tumors (Fig.4). Since these "transplanted" tumors were inserted artificially their volume, as well as the liver volume were known.
Theses scenes were transformed to slices again and saved in the DICOM format. A group of 10 senior physicians (five radiologists, four surgeons, one internist – grouped as radiologists and non-radiologists) had to evaluate these scenes at three different display settings: a) 2D : slices and multiplanar reconstructions b) 3D: shaded surface display c) using the VLSP. For a) and b) the Tiani J-Vision 3.3.13 Software (Tiani Inc., Vienna, Austria – http://www.tiani.com) was used. All physicians hat to estimate the ratio between the "transplanted tumor(s)" and the whole liver separately in 2D, 3D and using the VLSP. For all tasks were the needed time of the individual task was recorded. Additionally an Analysis of Variance (ANOVA) was performed.

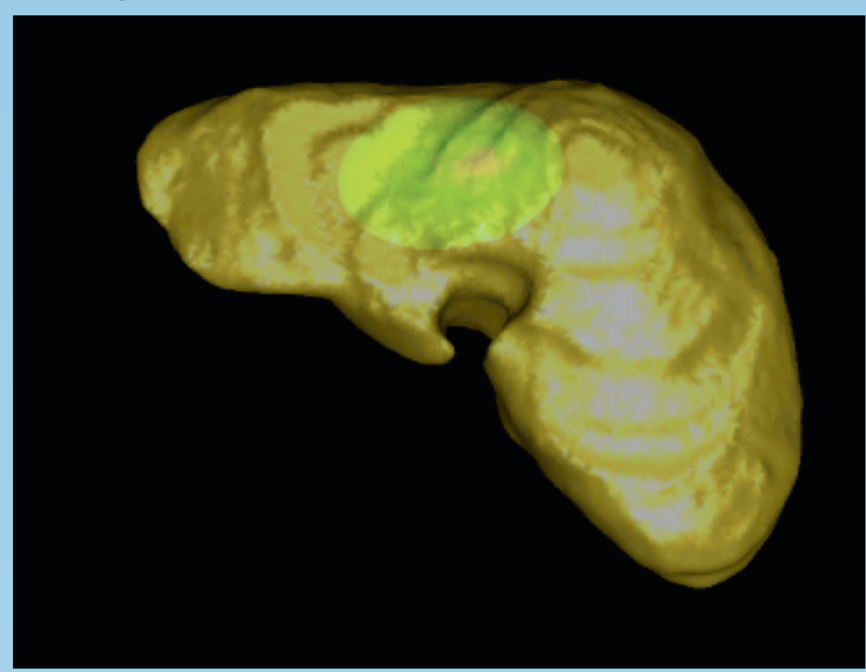

Fig.4: An 3D reconstruction, using shaded surface display) of an extracted liver surface with an "transplanted" tumor is shown.

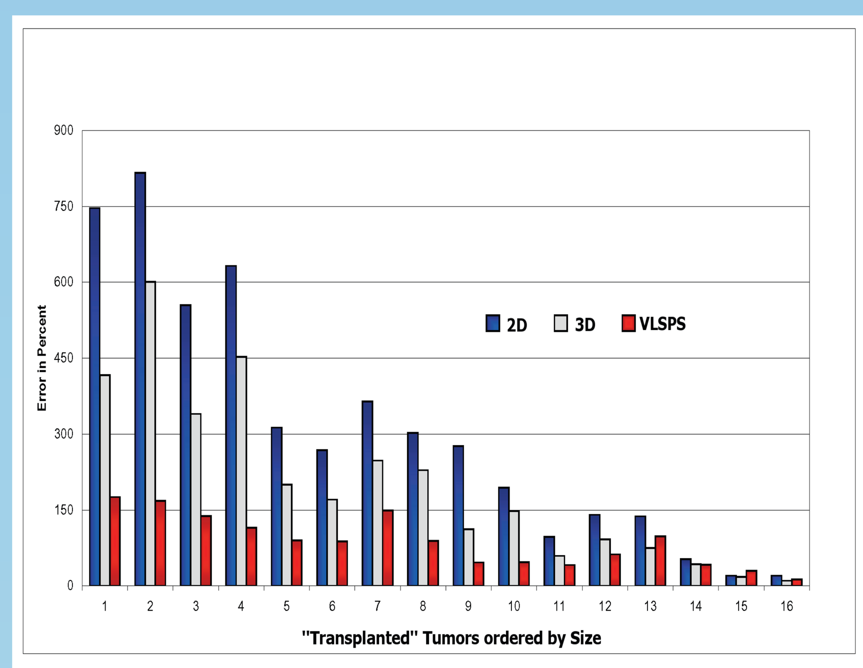

Fig.5: Chart displaying the performance as achieved by the different display systems, the "transplanted" tumors are ordered by size. As it can be expected, the performance increases if the ratio between the "transplanted" tumor and the liver decreases. But for all sizes the VLSP performs best.

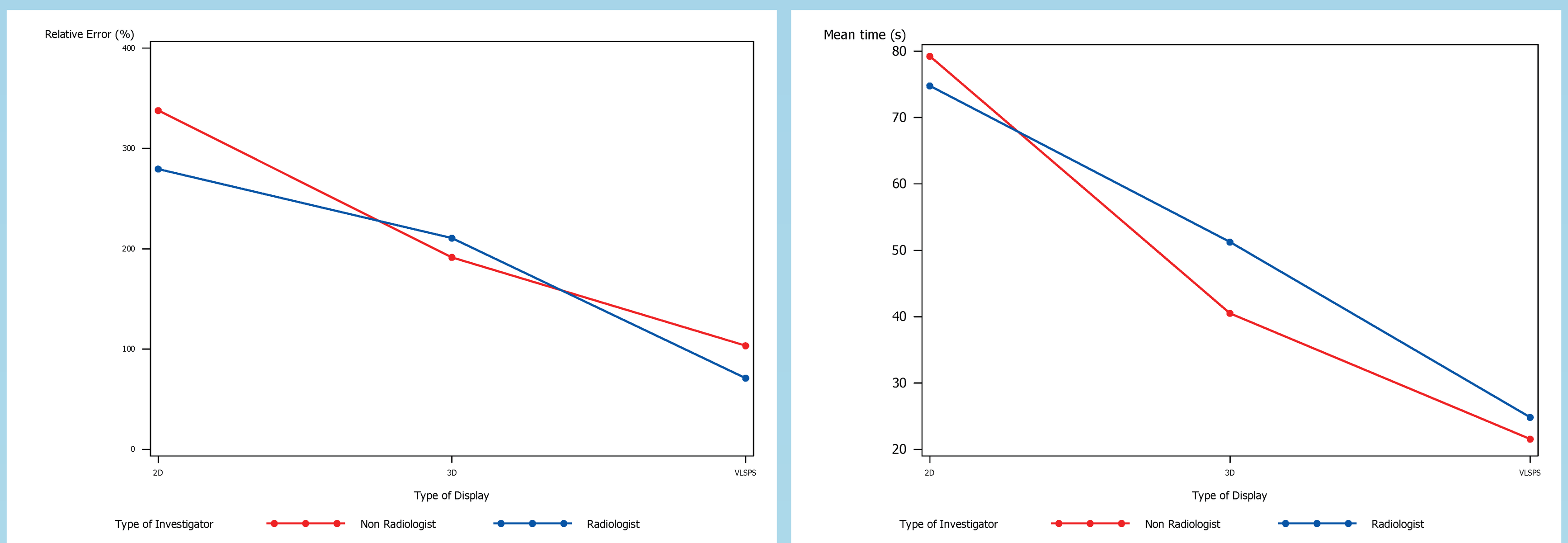

Fig.6: Achieved evaluation performance left: regarding ratio estimation in dependence of display system for different users well as right: the needed operator's time.

At ANOVA for the performance of the ratio estimation a statistically significannt effect for the type of display (2D, 3D, VLSP), the "transplanted" tumor size as well as a nested effect of the "transplanted" tumor size and type of display were found. Similar for the time requirements the type of display and a nested effect of the type of user and the scene were found to be significannt at ANOVA.

VLSP -- Conclusion:
- **VLSP represents a novel human machine interface**
- **VLSP offers major advantages for 3D editing regarding time amount**
- **VLSP enables better perception of size differences**
- **VLSP enables pereception and maybe therefore communication between radiologists and non radiologists.**

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