# The Virtual Liver Surgery Planner -- New Attacks to Old Problems


Erich Sorantin[1], Georg Werkgartner[2], Reinhard Beichel[3], Alexander Bornik[3], Bernhard Reitinger[3], Nikolaus Popovic[1], Milan Sonka[4]

1: Department of Radiology, Medical University Graz, Auenbruggerplatz 9, A-8036 Graz / Austria
2: Department of Surgery, Medical University Graz, Auenbruggerplatz 9, A-8036 Graz / Austria
3: Institute for Computer Graphics and Vision, University of Technology, Inffeldgasse 16, A-8010 Graz / Austria
4: Department of Electrical and Computer Engineering,University of Iowa, Iowa City IA 52242 / USA


**Introduction:**

Liver tumors accounts for a considerable number of death every year [1]. There are primary malignant liver tumors like hepatocellular carcinoma, most often arising as a complication of diseases leading to liver cirrhosis. Additionally almost any tumor can seed metastasis within the liver, colorectal cancer being on top of the list.

For many patients suffering from liver tumors surgery may represent the only curative approach, for the others only palliative, interventional techniques are available for local tumor control – eg cryotherapy, chemoembolisation, ethanol injection, radio frequency ablation just to name a few.

Individual treatment plans are based on laboratory results and imaging modalities like ultrasound, spiral computed tomography (S-CT), Magnetic Resonance Imaging (MRI) and Nuclear Medicine studies. Meticulous interpretation of the available imaging modalities is necessary in order to assess all aspects of the disease. Unfortunately liver tumors exhibit complex patho-anatomical relationships to surrounding vessels and bile ducts. Additionally the involved Couinead segments are mandatory to know, but the correct identification represents difficult task [2, 3, 4]. 3D reconstructions can help in this situation but hardly exhibit quantitative information. It has to be considered, that whenever surgery is not regarded to represent a suitable therapeutic approach, there will be not other curative treatment option.

Therefore an interdisciplinary team of radiologists, surgeons and engineers started the development of a system, which should enhance and augment the therapeutic decision process. Moreover, the system should not only allow to use new visualization technologies like augmented reality but should deliver quantitative data like number of involved segments, total liver volume and tumor volume too.

***This was the birthday of the "Virtual Liver Surgery Planning System" (VLSPS).***

**Systendescription:**

Helical CT forms the basis for all postprocessing steps -- the workflow can be found at Fig.1.

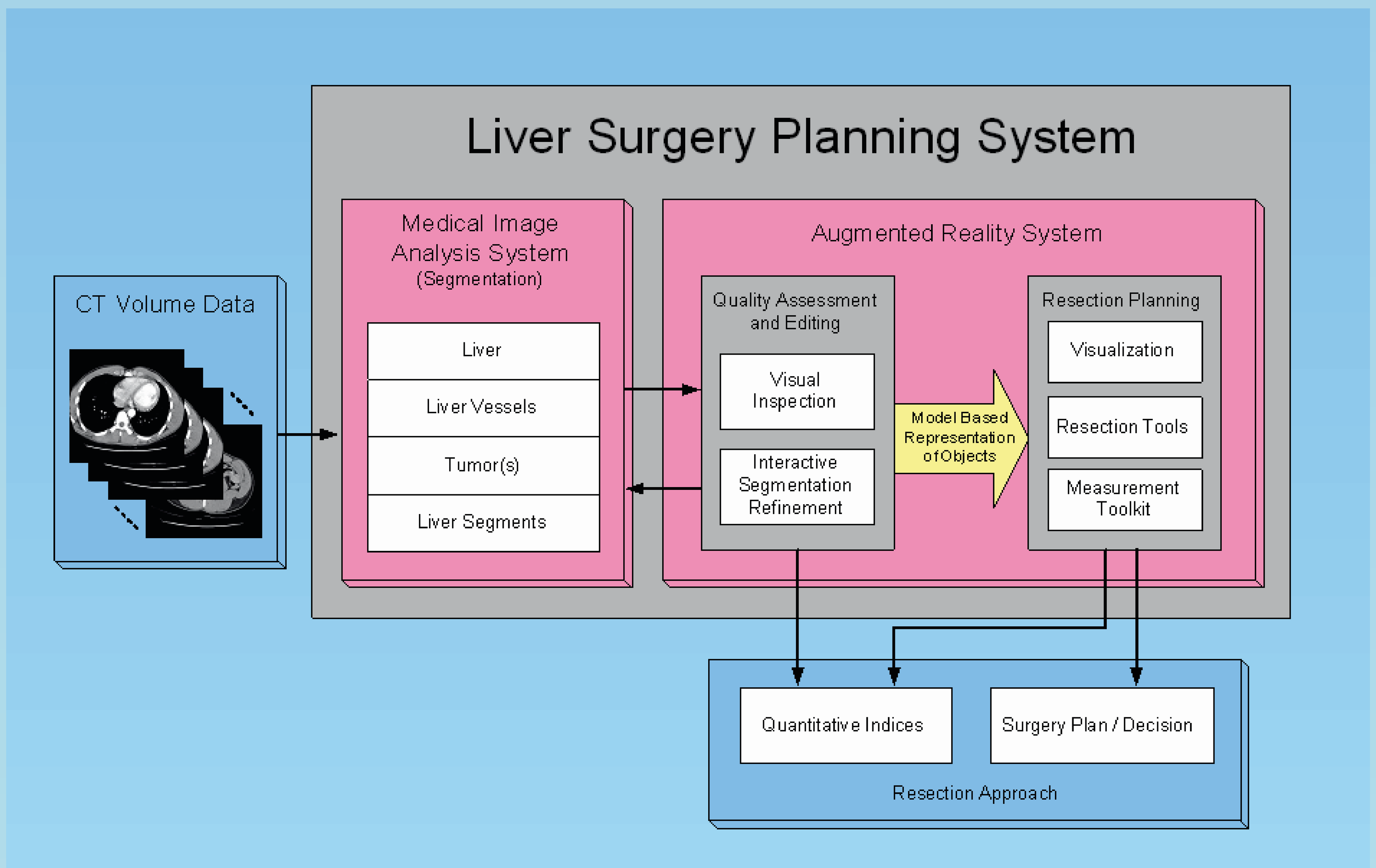


Fig. 1: VLSPS work.ow – the left hand stack of Spiral – CT images represent data acquisition, the pink part in the center of the .gure outlines the different data processing steps. The blue part on right lower corner symbolizes the quantitative results generated by the VLSPS and all parts together lead to a decision regarding the best suited therapeutic approach.

For visualization an augmented reality system is used, details and components are given in Fig. 2. The head mounted display consists of two "see through" monitors (800x600 pixels each). Both monitors act as part of the graphic system, which is feed by the corresponding computer with two stereoscopic images.

These monitors are fixed on a helmet, which contains the tracking targets too. The cameras emit infrared flashes, which are reflected by the tracking targets. Based on the shape of the tracking targets as well as the time as needed for reflection of the infrared flashes the system calculates the operator's position within the 3D space.

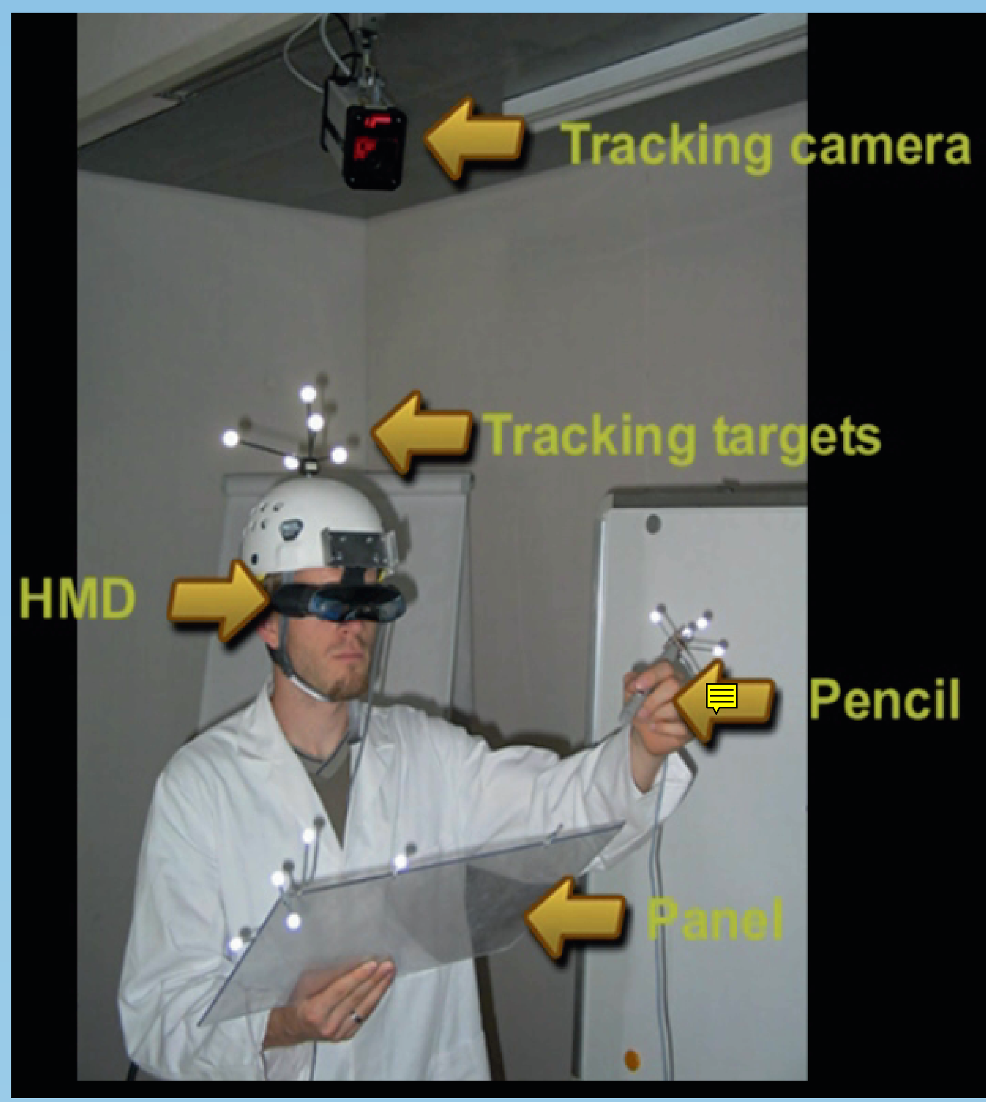


Fig. 2: Components of the augmented reality system – operator wears a head mounted display (HMD), on the top of the HMD tracking targets are .xed. The tracking cameras (usually four) send infrared .ashes, which are re.ected by the tracking targets. This information forms the basis for calculation of the operator's position within the 3D space. The panel represents the interface to the system and covers two tasks, depending on it's position (more details on Fig. 6 and7): one one side it displays action buttons and sliders for the operator, if .ipped it acts as a cutting device for display of surrounding Spiral – CT data. All actions are carried out using a virtual pencil.


Fig. 3: The action button side of the PIP is shown = . the pencil is used in order to activate the different functions.

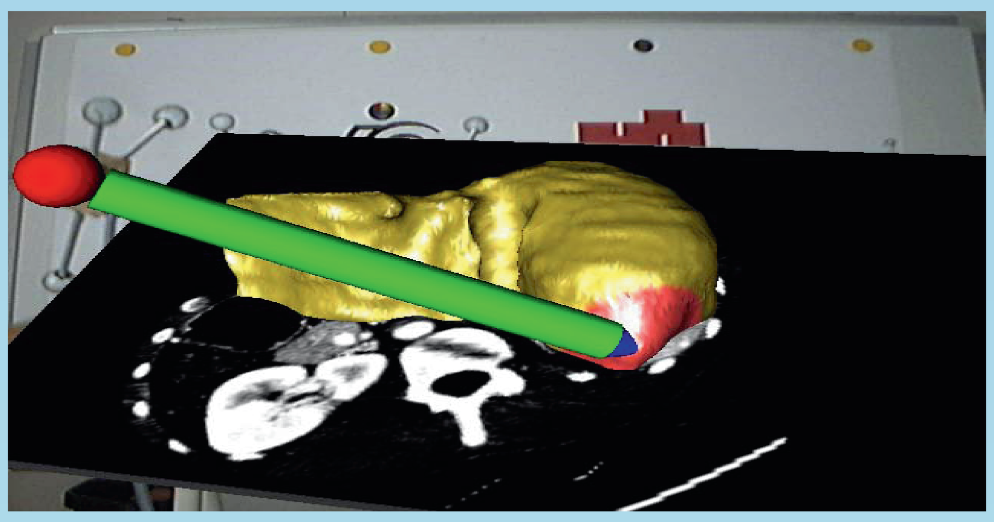

Fig. 4: A 3D reconstruction of a liver as well as the pencil, which has activated a part of the liver surface for editing, is shown. The source CT data are displayed as selected by the PIP cutting plane.

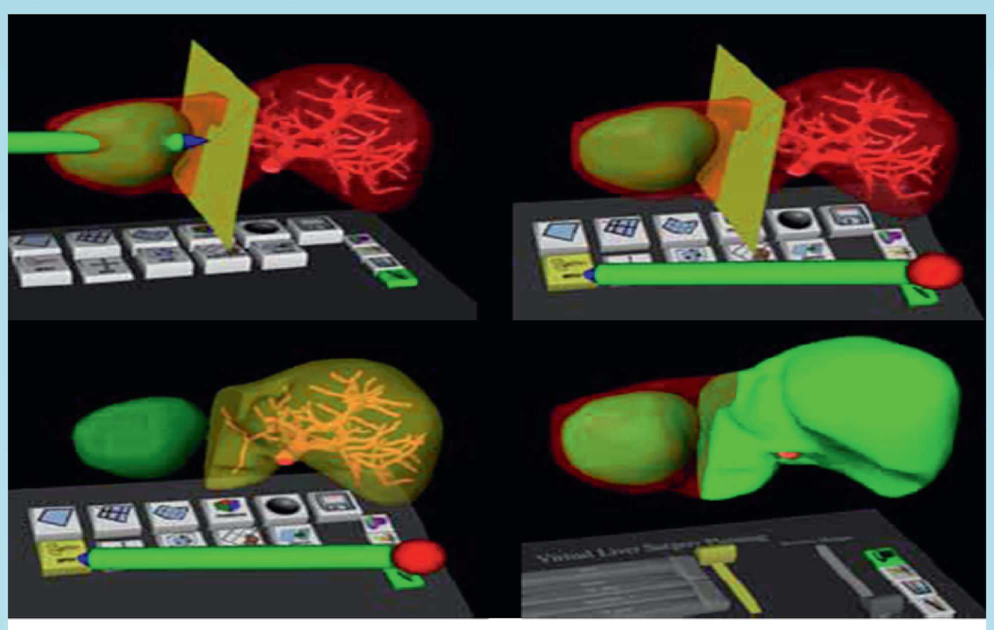

Fig. 5: Another scene from the simulation process – the different steps of a hemihepatectomy is depicted (liver, tumor, virtual pencil, PIP).

These calculations are performed in real time and after every change of the operator's position the stereoscopic images are updated and sent to the "see through" monitors.

For system interaction the operator uses the so called "personal interaction panel" (PIP), depending which side of the panel is up the action behavior is changed: a) action buttons and sliders, which are activated by the touch of a virtual pencil, allow to change the scene eg. opacity of objects, performing measurements and much more (Fig.3). b) If the panel is flipped, it acts as a cutting plane in order to display the source image data (Fig.4).

Tools were implemented in order to assist the phyiscian at the virtual liver surgery planning step (Fig.5).

**Conclusion:**

An interdisciplinary, inter-national team started to a new dimension by producing the ***"Virtual Liver Surgery Planning System".*** This system exploits new emerging technologies in order to improve patient care.

**Literature:**


[1] World Health Organisation. World health report, http://www.who.int/whr/2004/en. Technical report, World Health Organisation, 2004.
[2] Lars Fischer, Carlos Cardenas, Matthias Thorn, Axel Benner, Lars Grenacher, Markus Vetter, Thomas Lehnert, Ernst Klar, Hans-Peter Meinzer, and Wolfram Lamade. Limits of Couinaud's liver segment classi.cation: a quantitative computer-based three-dimensional analysis. J Comput Assist Tomogr, 26(6):962–7, 2002.
[3] O. Rieker, P. Mildenberger, C. Hintze, K. Schunk, G. Otto, and M. Thelen. [Segmental anatomy of the liver in computed tomography: do we localize the lesion accurately?]. Rofo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr, 172(2):147–52, 2000.
[4] H. Strunk, G. Stuckmann, J. Textor, and W. Willinek. Limitations and pitfalls of Couinaud's segmentation of the liver in transaxial Imaging. Eur Radiol, 13(11):2472–82, 2003.



**Corresponding Author:**

Univ.-Prof.Dr.Erich Sorantin
Dep. of Radiology
Medical University Graz
Auenbruggerplatz 9
A . 8036 Graz
Austria

**Email:**
erich.sorantin@medunigraz.at