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FRAUNHOFER INSTITUTE FOR COMPUTER ARCHITECTURE AND SOFTWARE TECHNOLOGY FIRST

ENDOGUIDE

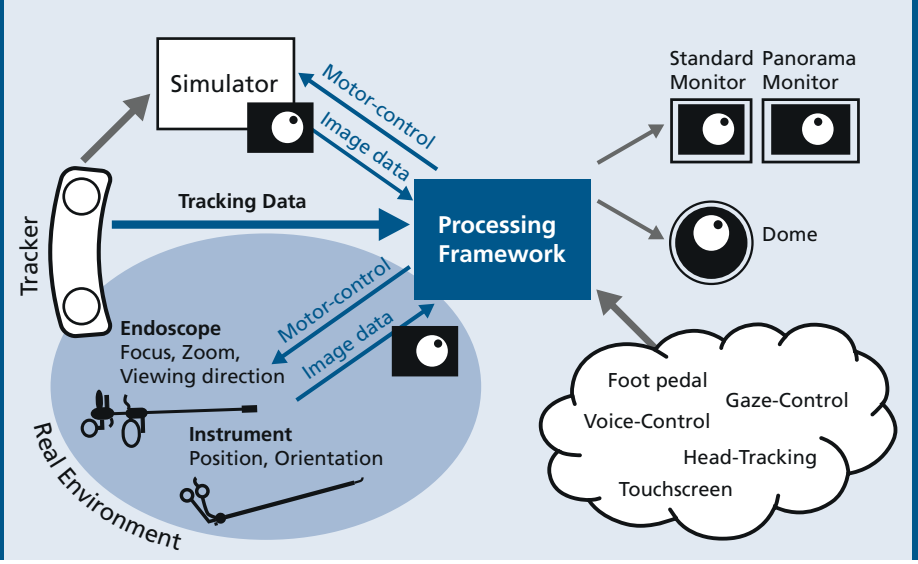
Minimally invasive surgery has considerably gained in significance in recent years. Such procedures have the potential to accelerate the healing process and to reduce hospitalization times. However, surgeons are still facing challenges of limited orientation and difficult navigation. Visual feedback is solely provided by the endoscope's two-dimensional camera image: the field of vision is restricted, the perspectives of doctor and endoscope do not match and the surgeon is unable to control the endoscope which is held by an assistant.
To overcome these obstacles, a computer-based endoscopic system with a 360-degree field of view is currently being developed in the BMBF (Federal Ministry of Education and Research) project »Endoguide«. It consists of an endoscope with a movable camera, a processing framework for real-time processing of image data and intuitive user interfaces. The endoscope is no longer held by an assistant but is mounted to a fixture while electric motors control the viewing direction, focus and zoom. Control is carried out through hands-free interfaces such as voice input and head- or eye-tracking. A simulator is used in development which realistically reproduces all system components, i.e. the functions of endoscope and camera, the instruments and their control and the operative area including organs.

Endoguide Processing Framework

A highly efficient, component-based software platform called »Endoguide Processing Framework« is the centerpiece of the system. The framework's flexible architecture enables users to add or remove components or functional groups even while the system is running. Communication between components was organized in a network with each module defining its input and output data. Real-time processing of the HD videos was realized through GPU processing. For this purpose, Fraunhofer FIRST is developing image processing algorithms that are close to hardware which are specifically tailored to the parallelized hardware of GPUs and multi-core computers. Independent functional groups (e.g. autofocus or instrument tracking) are executed concurrently on different processor cores in order to take full advantage of the capacity of multi-core architectures. A number of innovative functions for the endoscopic system are facilitated by the Endoguide Processing Framework.

Image- or Tracker-based Monitoring of Instruments

Surgical instruments can be located on endoscopic images and their motions can be monitored. This can either be done with the aid of markers that are captured by an optical tracking system, calculating the position of the instruments in relation to the endoscope, which is itself equipped with markers. This technology can serve as a »parking assistant« for doctors and help locate and position the instruments in the camera image. Another option is utilizing



A highly efficient, component-based software platform called »Endoguide Processing Framework« is the centerpiece of the endoscopic system

image information (color markers on the instruments) to locate the instruments. Image processing algorithms detect the instruments' position as soon as they are visible in the image and facilitate automatic tracking of the camera image (adaptive region-of-interest selection). This ensures that the relevant region is always at the center of the image, allowing the doctor to fully focus on his surgical task without having to bother with the operation of the camera.

Augmented Reality

Procedures using augmented reality are employed to provide doctors with additional information during surgery. Annotations of pre-operative data prepared by the surgeon or another doctor in surgical planning can be superimposed over the live image of the procedure. However, pre-operative data are rarely consistent with the patient's current state due to the deformability and position-shifting of organs, particularly as a result of respiration and heartbeat. A full superimposition of images would thus inevitably lead to distortions, which is why only textual comments or rough markers are provided in the live image. Pre-operative data can also be displayed on a separate screen from a perspective identical with the live images, facilitating the easy correlation of information.

360° Panoramic View

The endoscopic system generates 360° panoramic images in order to provide surgeons with an image of the operative area that is as realistic as possible. The endoscope's adjustable tip and movable shaft enable a fully automatic scan of the abdomen. The camera's individual images are combined in a panoramic image with a field of vision of 360° x 270°. Intelligent algorithms ensure that the individual images are adjacent to each other with pixel accuracy (feature-based image mosaicking). So-called »Ghosting« (double images), which is caused by the optical system's parallax, is significantly reduced through multi-scale blending. The surgeon is thus provided with a 360° view of the inside of the patient which can be displayed on a second standard screen, a head-mounted display or a dome-shaped projection surface in the operating room. The live image is additionally displayed at the correct position in the panorama.

Overview

- 360° Panoramic View
- Automatic monitoring of instruments and autofocus
- Hands-free operation (head or eye-tracking)
- Enhancement of image data through augmented reality
- Real-time HD video processing on multi-core processors

Project Partners

- How to organize GmbH
- Karl Storz GmbH & Co. KG
- MIC – Clinic for Minimally Invasive Surgery
- Paul Peschke GmbH
- TU Berlin – Institute of Micro Technology

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