Section: **Visualisierung**

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Abstract-Title:
NEUE TECHNIKEN DER 3-D ENDOSKOPIE IN DER MINIMAL INVASIVEN CHIRURGIE
A NOVEL APPROACH TO 3-D ENDOSCOPY IN MINIMALLY INVASIVE SURGERY

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Abstract-Text:
Purpose:
Minimally invasive surgery offers many advantages for patients but there are also limitations like the two-dimensional display, the restricted field of view and reduced depth perception. The aim of research is a computer-aided reduction of these limitations during videoendoscopic interventions and the display of a three-dimensional sight of the operating field. The pre-condition for high quality presentation of sterical images is the acquisition of range data combined with visual information.Currently 3-D information is extracted by the surgeon himself based on his knowledge of the anatomy of the operation area and on optical effects like shadows or occlusion. Instead of this artificial 3-D impression we want to propose a method for gaining metric 3-D information by using a multi-sensor endoscope as transmitter for signals enabling the acquisition of range data and image data simultaneously.

Method:
A conventional videoendoscopic system was extended by two technologies for aquiring metric data: a time-of-flight (TOF) camera and a new generation of opto-electronic elements (photonic-mixer-device, PMDs). Each element individually measures the turn-around time of the modulated light via phase delay and provides an amplitude value indicating the quality of the measured range. In order to provide Augmented Reality the 3-D reconstruction gained by the data from the TOF endoscope is registered with modalities acquired pre-operatively (e.g. CT/MR data). The computation of the 3-D reconstruction can take in account the dynamics and the movements of the operation area. The effects of averaging frames over time was considered. The calibration routine was tested for the ocular provided by PMD Tec and the ocular of an endoscope camera. In addition a proof of concept was given by registrating a TOF camera image plane and the standard camera image plane.

Results:
All tests were carried out with a PMD3k_s from PMD Technologies GmbH. The camera has a lateral resolution of 48x64 pixel.The effects of averaging frames over time were measured. The average amplitude value of each image was approximately 650. Averaging frames over time increased stability of amplitude information. The experiments were done

at an integration time of 7000ms and of 1400ms. The average amplitude value of the images increased while the range of sensor noise remained similar to the values obtained at an integration time of 7000ms.The calibration routine was tested for the ocular provided by PMD Tec and the ocular of an endoscope camera. The mean and standard deviation for focal length and principal point computed with different calibration routines were obtained. The deviations were within the sub-millimeter range.Finally an example was given of the registration of a TOF camera image plane and a standard camera image plane. After calibrating both cameras the pixel of the TOF camera were back-projected and then projected into the webcam image plane. This served as a proof of concept.

Conclusion:
The introduced PMD technology and the TOF principle permit the acquisition of range information via an endoscope at 15 to 30 fps based on evaluation of the phase delay of modulated light. Several clinical benefits were found as well as certain signal transmission problems which were observed with the prototype TOF endoscope due to the poor transmission properties of endoscopes in the infrared spectrum. A method for calibrating the TOF camera, which is the key component of a TOF endoscope, was proposed. By using amplitude as well as range information provided by a TOF camera, a more reliable calibration can be achieved. Finally, a proof of concept for the registration of range and image data was given.