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Novel Assistive Device for Tomographic Ultrasound Neck Imaging vs. Freehand

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Introduction

Ultrasound (US) systems that utilize tracking methods to produce 3D volumes are called 3D or tomographic ultrasound systems (tUS). The tUS systems use US systems coupled with tracking systems (electromagnetic(EM), optical, mechanical and hybrid) to reconstruct 3D volumes from 2D US image slices. Initial prototypes developed were tested but did not yield the desired results. Based on those initial results this paper deals with the use of a systematic designing approach to conceptualize and build an improved prototype for assisted 3D US acquisitions.

Methods

The new prototype was designed based on the guidelines specified by VDI 2221 by the Association of German Engineers. This designing approach starts with a systematic task analysis to generate a comprehensive list of requirements and boundary conditions for the design. The most important requirements were that the patient's head / neck must be stable during the scanning process, the circulation radius of the US probe needs to be adaptable to fit different neck sizes, the design must not include any magnetic parts materials because of their interference with the electromagnetic tracking system and the device needs to be put on / taken off in 5 steps or less and without use of additional tools.

Results and Conclusion

The prototype was tested on 5 male subjects. The test setup included two scan acquisition approaches: freehand tUS scans and assisted scans with the prototype. In this work we used an EM tracking system (PIUR Imaging, Vienna, Austria) coupled with an US system (9L probe and Logiq E9, GE Wisconsin, USA). Experiments from both scanning methods (freehand and assisted) generate measurable results. The difference lies in the reconstruction and subsequent visualization of the 3D volumes. Volume reconstruction and visualization from freehand scans appear more to have more irregularities and deformations. Assisted volumes depict a more uniform reconstruction and visualization. This is due to the fact that the probe always follows a 'standard' guided path. If this acquisition method and prototype can be further developed it could be also used for assessing other body parts like internal structures in the abdominal region.

Impact of artificial airway resistances on regional ventilation distribution during airway closure

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Introduction

Electrical impedance tomography (EIT), a non-invasive and radiation-free imaging technique can be used in pulmonary function monitoring for determining regional ventilation distribution within the lung. Gold standard in pulmonary function monitoring is spirometry/body plethys-mography, a method using forced breathing maneuvers to obtain global lung function parameters. However, this method is heavily dependent on the co-operation of the patients.

Methods

Within this observational study, a method under normal breathing was tested with 5 healthy volunteers, which provides regional information about ventilation distribution. The occlusion method Rocc, a method for determining airway resistance, was used to create a short-term airway closure. Regional ventilation during the airway closure was examined with EIT. Simultaneously four different artificial airway resistances were used to simulate airway obstructions.

Results

Results show that EIT in combination with the ROcc method is suitable for the detection of regional differences in ventilation during airway closure for all four artificial airway resistances. Although the sum of relative impedances at the end of the shutter maneuver are smaller (nearly -0.100 AU) for the airway resistances Ø 12.5 mm, Ø 10.5 mm and Ø 9.5 mm than for the smallest one with Ø 30.0 mm (~ -0.070 AU), the changes in impedance from the start to the end of the shutter maneuver differs only slightly between the four artificial airway resistances. All impedance changes are in the range of 0.100 to 0.130 AU.

Conclusion

The combination of EIT and the ROcc method provides not only global parameters such as airway resistance under normal breathing conditions, but also results of regional ventilation, which could enable the identification of areas affected by airway obstructions. However, the obtained results indicate that EIT might be a useful tool in the diagnosis and follow-up of obstructive lung diseases.

Global Inhomogeneity Index Evaluation of a DCT-based EIT Lung Imaging

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Introduction

Combination of imaging modalities of CT and EIT to roughly restrict EIT image to CT generated anatomy generates a novel DCT-based EIT approach. This approach includes detailed prior information about both the thorax contour and lung shape obtained from the discrete cosine transformation (DCT) of the CT image, which as a side effect is resulting in improved interpretability for clinicians. The objective of this work is to evaluate the plausibility of a novel DCT-based EIT lung imaging method against the traditional Gauss-Newton one step method in clinical settings. In a first step Global Inhomogeneity (GI) index is used for comparison, which indicates the difference of the volume distribution within a ventilation period.

Methods

Taken retrospectively from a former study, EIT data was evaluated using both reconstruction methods. For different phases of ventilation, EIT images are analyzed with respect to the global inhomogeneity (GI) index for comparison.

Results

A significant less variant GI index was observed in the DCT-based method, compared to the index from classical method.

Conclusion

The DCT-based method generates more accurate lung contour yet decreasing the essential information in the image which affects the GI index. These preliminary results must be consolidated with more patient data in different breathing states.

A Deep-Learning Approach to Detect Fiducials in Planar X-Ray Images for Undistortion of Conventional C-Arm Images

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Introduction

In some applications such as 2D-3D registration, undistorted images are required to achieve optimal results. These types of images can be obtained from a distortion-free C-arm (flat-panel detector) or by undistorting the images given from a conventional C-arm (analog image intensifier.) Undistorting images require a plate with fiducials connected to the C-arm detector. Detecting fiducials is affected by differences in the image contrast due to elements in the background. Therefore, the results vary from image to image and could require manual tuning of parameters. We propose a deep-learning approach for detecting undistortion-plate-fiducials in X-ray images to overcome the drawbacks previously stated.

Methods

We created an undistortion plate of 60 fiducials in a grid of 8x8 without corners. We used a Ziehm Vision C-arm and took 1120 X-Rays in different poses of the C-arm. Every X-ray was afterward cut into 60 sub-images of 32x32 pixels, and each of the sub-images was labeled with the X and Y coordinate of the fiducial position. These 67200 sub-images were used for training a convolutional neural network (CNN). The topology used consisted of three layers of convolutions plus max-polling and, in the end, a fully connected neural network with three hidden layers.

Results

Comparing the CNN and a traditional image processing method based on the Hough Circle algorithm, we found that the detected fiducials using the traditional method give a similar fiducial positioning error. Nevertheless, the fiducial detection rate goes from 89.7% using the traditional method to 100% with the developed CNN.

Conclusion

We propose to detect undistortion plate finducials in planar X-Ray images coming from conventional C-Arms using a Deep-Learning approach. The results show that the detection rate and precision of our deep-learning approach guarantee the undistortion of conventional C-Arm images.

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Deep-learning based reconstruction of the stomach from monoscopic video data

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Introduction

For the gastroscopic examination of the stomach, the restricted field of view related to the „keyhole“ perspective of the endoscope is known to be a visual limitation. Thus, a panoramic extension can enlarge the field of vision, supports the endoscopist during the examination, and ensures that all of the inner stomach walls are visually inspected.

Methods

To compute such a panorama of the stomach, knowledge about the geometry of the underlying structure is required. Structure from motion one an approach to reconstruct the necessary information about the 3D-structure from monocular image sequences as provided by a gastroscope. We examine and evaluate an existing deep neuronal network (DeMoN) for stereo reconstruction, in order to approximate the geometry of stomach parts from a set of consecutive acquired image pairs from gastroscopic videos.

Results

We extracted 48 image pairs from gastroscopic video streams of the stomach which were reconstructed using the DeMoN network. Evaluation was done qualititative. Additionally we manually 3D-scanned a silicon stomach phantom and compared the expected shapes with the reconstructed shapes

Conclusion

We were able to yield 3D- approximations of stomach parts based on pairs of monocular gastroscopic images. The quality of the obtained depth maps is sufficient for a subsequent generation of 3D-panoramas in most of our test cases, even though the DeMoN network was originally trained with datasets from a different domain. Only small motions of the gastroscope in a short time interval are were necessary to extract sufficient information for a 3D-reconstruction.