Section: **Intraoperative Bildgebung**

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Abstract-Title:
ANGIOGRAPHIC 3-D BLOOD FLOW MEASUREMENT – CONCEPT AND PRELIMINARY EXPERIMENTSANGIOGRAPHISCHE 3D-BLUTFLUSSMESSUNG – KONZEPT UND VORBEREITENDE EXPERIMENTE

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Abstract-Text:
Purpose
In this article a new approach for determination of blood flow out of angiographic movies is proposed. The system is supposed to assist the radiologist/cardiologist during interventional therapy. It features intraoperative image acquisition, 2-dimensional flow determination, and 3-dimensional reconstruction.
Potential application areas are angiography for radiology (peripheral vessels), cardiology (coronary imaging) und neurology (neurovascular imaging). Angiography is the gold standard to visualize vascular structures by contrast enhancement of the vessel. Additional flow measurements promise benefits to evaluate stenosis severity, end organ perfusion and the interventional strategy.

Method
The principle of navigated imaging for angiography has been described in [1][2]. With the help of position measurement and calibration of imaging system the position of any voxel inside the reconstruction volume will be determined by reconstructing paths of X-ray beams. The knowledge of orientation and position of the reconstruction volume vol will supersede the registration process. Fig. 1a shows the principle and Fig. 1b the implementation of this approach for biplane angiography.
In second step the recorded 2-d image sequences displays the flow of contrast agent in each projection. The determination of blood flow in angiographic movies is similar to thermo dilution technique. In the supposed approach here, contrast agent will be used as indicator instead of a cold bolus as used in thermo dilution technique. The determination of 2-d flow vectors is divided into the following steps:
- Determination of reference signal
- Detection/segmentation of positions with flow
- Determination of 2-d flow vectors The last step of the proposed algorithm is the 3-d reconstruction of vessel tree and 3-d flow vectors out of the two 2-d flow vector sets. Because each of the flow vectors v is defined by two projection vectors v1 and v2 the values of v are over-determined. Due to this, ambiguities in the spatial assignment of contrast agent/vessels can be solved.
In Fig. 1c this principle is shown in a simplified example. The images are taken with y-axes parallel to each other and the x-axes perpendicular. The reconstructed slice is placed perpendicular to both image planes.

Results

The presented method was evaluated using a self-developed flow phantom, which consists of silicone tubes with different diameters (4 and 1 mm, respectively). The circulation was produced by a standard in-door fountain pump (Heissner, Lauterbach, Germany) with a constant flow rate (water supersedes blood here). The contrast agent was injected with a Judkins right coronary catheter (Performa 5 F, Merit Medical Systems, South Jordan, UT, USA). Fig. 2 shows the temporal distribution of the contrast agent in the angiographic movie (selected images out of 85 images). In this experiment the starting point of contrast agent flow is on the top (see arrow in the leftmost images). A constriction was built into the flow phantom on the right (cambered brackets in the rightmost images). The 3-d reconstruction and qualitative benchmark is shown in Fig. 3.

Conclusion

The preliminary experiments showed the feasibility of the 3-d angiographic flow measurement, but are still limited to some problems. The detection depends on the ratio of contrast injection time and total imaging time and can be substituted by a reference signal. Therefore the starting point has to be determined by measuring the tip of the catheter with electromagnetic tracking [3].

The result shows various artifacts in vessels flexion and starting point. Artifacts in the neighborhood of catheter tip result from overfilling the vessel with contrast agent.

Another aspect is the difference between viscosity of blood and contrast agent, which may differ up to 50 % [4]. A compensation function has to be found.

References

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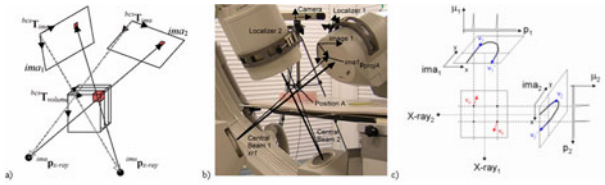
[4] Wille F. (1990): Einfluß von Röntgenkontrastmitteln auf die elektromagnetische Blutflußmessung, Diss., Univ. of Göttingen, Göttingen, Germany, 1990

Figures

Fig. 1: a) Principle and b) implementation of navigated imaging for angiography, and c) Reconstruction of 3-d vessel tree and velocity vectors based on the known spatial position of the projection imagesFig. 2: Temporal distribution of contrast agent in angiographic movie with 85 images (top: five images of the sequence from floor mounted C-arm, bottom: images of the sequence at same moment from the ceiling mounted C-arm)Fig. 3: 3-dimensional reconstruction of vessel tree and 3-d velocity vectors of the experiment; the local speed inside the vessel is represented by the vector’s colour: from blue to red signifies from slow to fast

Bild 1/JPG



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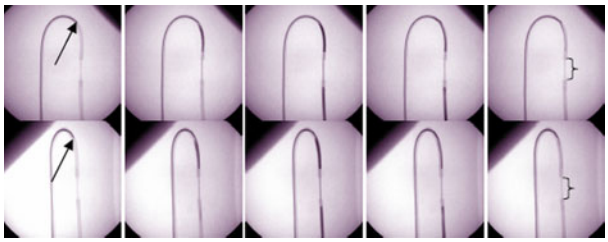

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