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A Methodology and Clinical Dataset to Evaluate Preoperative Registration Accuracy in Laparoscopic Liver Resection

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Introduction

Augmented Reality (AR) is used to assist Laparoscopic Liver Resection (LLR) by registering a preoperative 3D model with laparoscopic images. Evaluating the accuracy of the registration methods requires measuring Target Registration Error (TRE). Previous works evaluate TRE on simulated, phantom and animal data but not on clinical data. Our contribution is methodology for groundtruth acquisition using Laparoscopic Ultrasound (LUS) in clinical LLR, two evaluation criteria, a two-patient dataset and an evaluation of two existing registration methods.

Methods

We acquire groundtruth using LUS coregistered with the laparoscope, as shown in figure 1. Coregistration is achieved using a checkerboard stuck on the distal end of the LUS probe. The LUS probe calibration is performed using [1] and the LUS pose is estimated using EPnP. Data collection was supported by an ethical approval with ID IRB00008526-2019-CE58 issued by CPP Sud-Est VI in France. We propose two evaluation criteria: an inclusion criterion and a measure of TRE (see figure 2). The inclusion criterion is binary: it is passed if and only if all the LUS tumour profiles lie within the registration-predicted tumour augmented by the oncologic margin of 1 cm. The TRE is computed as the average minimal distance between each LUS tumour profile and the registration-predicted tumour volume.

Results/Discussion

The average position error in our LUS registered images is estimated as 0.98 mm, which is far better than the measured errors for the state-of-the-art registration methods, making our dataset relevant for their evaluation. We ran a preliminary evaluation of two registration methods: Adagolodjo et al. [2] and Koo et al. [3]. The results are given in figure 2. Both methods failed the inclusion criterion for both patients in the dataset. This is not surprising since the criterion is difficult to meet and these methods only use one image to solve registration, hence are prone to registration uncertainty. The TRE measurements show that the registration-predicted tumours are out of the 1 cm oncologic margin with reasonable standard deviation over the dataset. In light of these preliminary results, we conclude that improvements in the accuracy of registration methods is needed for accurate gesture guidance.

Conclusions

The proposed methodology and dataset are the first of the kind. They give a TRE measure on clinical LLR data. In future work, we plan to expand our dataset, varying the type, shape and location of the tumours, and to compare more registration methods such as [4]. Importantly, we plan to make a public release of our dataset and evaluation method to aid researchers standardise the evaluation of registration.

Disclosure

I or one of my co-authors have **no financial interest** or **relationship** to disclose regarding the subject matter of this presentation.

Affix

References

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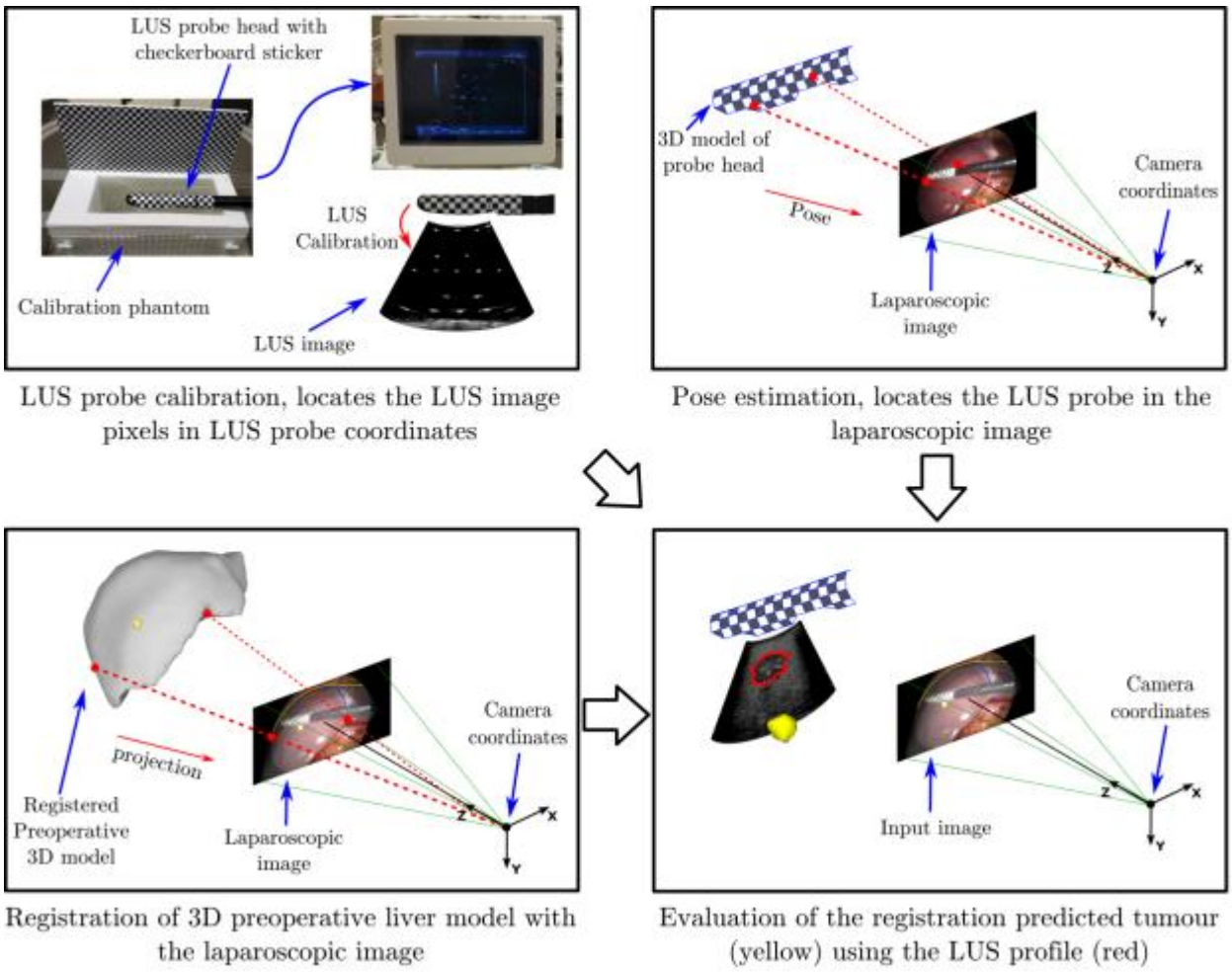
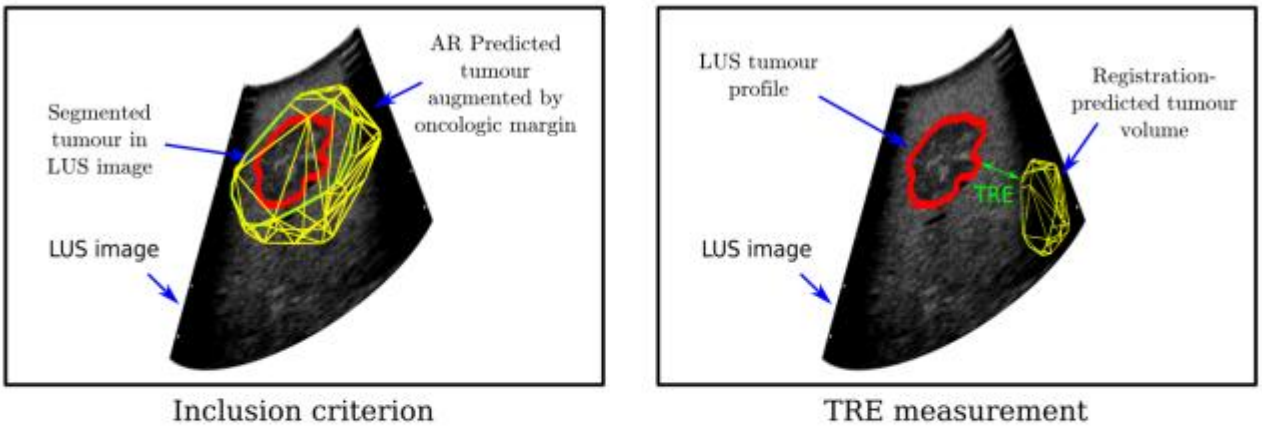


Figure 1

Overall methodology for groundtruth acquisition and registration evaluation.



Inclusion criterion TRE measurement

Method	Patient 1			Patient 2			Overall		
	Inclusion	Avg TRE	SD TRE	Inclusion	Avg TRE	SD TRE	Inclusion	Avg TRE	SD TRE
Adagolodjo et al. [2]	Failed	5.33 mm	2.98 mm	Failed	34.41 mm	15.15 mm	0 of 2	19.87 mm	20.56 mm
Koo et al. [3]	Failed	5.77 mm	3.67 mm	Failed	36.04 mm	16.20 mm	0 of 2	20.90 mm	21.40 mm

Preliminary evaluation results for two existing registration methods

Figure 2
Evaluation criteria and results.