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Reproducibility Evaluation of Palpation of Anatomical Landmarks for Estimation of the Patient Location

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Abstract

This study is about estimating the reproducibility of finding palpation points of three different anatomical landmarks in the human body (Xiphoid Process and the 2 Hip Crests) to support a navigated ultrasound application. On 6 test subjects with different body mass index the three palpation point were located five times by two examiners. The deviation from the target position was calculated and correlated to the fat thickness above each palpation point. The reproducibility of the measurements had a mean error of ≈13.5 mm +- 4 mm, which seems to be sufficient for the desired application field.

Keywords: Surgical Navigation, Palpation, Anatomical Landmarks

1 Problem

In many clinical applications of surgical navigation, the determination of the patient position and its tracking is a crucial step. In most surgical applications, a reference body is attached to the patient in a reproducible way, e.g. by using bone screws, head clamp, jaw splint, or headbands. Some of those techniques work for different sessions over time (e.g. the jaw splint or bone screws) whilst others like headbands are not guaranteed to be positioned at the same position in the next session. In such cases it is necessary, to calibrate the reference body to the anatomy of the patient for each examination in a reproducible way.

In our use case, we want to track the position of an ultrasound (US) probe in relation to the patient body in order to be able to produce reproducible ultrasound images in different examination sessions [1]. Since we are focusing on abdominal US in a general internal medicine setting, we cannot use invasive techniques like bone screws or expensive techniques like individually produced jaw splints. Furthermore, there are little anatomical landmarks on the upper body, which are clearly visible on one hand, and invariant against body posture on the other hand (e.g. the belly moves depending on the patient posture). Therefore, we decided to use palpation points as anatomical landmarks, in our case the Xiphoid Process and the two Hip Crests. To evaluate whether this approach is feasible, we evaluated the reproducibility of the palpation of the three anatomical landmarks in a first evaluation study.

2 Material and Methods

We recruited six test subjects with different body mass index (BMI) [2], categorized in low BMI (<= 18.5), neutral BMI (18.5 - 24.9) and high BMI = from 25), one male and one female test subject in each category. For this study, all test subjects agreed on the participation in the study and the usage of the gathered data. For each test subject, each palpation point was palpated five times by two different examiners. The examiners were computer science students, trained by a clinical expert in ultrasound examinations prior to the study. The test subjects did not move during the test and the position of the palpation points was measured using an optical tracking system (NDI Polaris Vicra) and the software NDI Track for reading the position values. For each palpation point the fat thickness was measured using an US device (esaote MyLab Sat) which was also used to confirm the correct palpation reference point.

3 Results

The reproducibility of the measurements had a mean error of ≈13.5 mm +- 4 mm (14.8 mm for examiner one and 12.4 mm for examiner two) calculated over all palpation points. Figure 1 (left) shows the distribution of errors. Figure 1 (right) shows the correlation between measured fat thickness and measurement accuracy.

Mean time for the measurements including ultrasound verification and fat measurement per test subject with BMI < 19 is 433.8s, for BMI 19-25 436.2 and for BMI >25 535.8s.

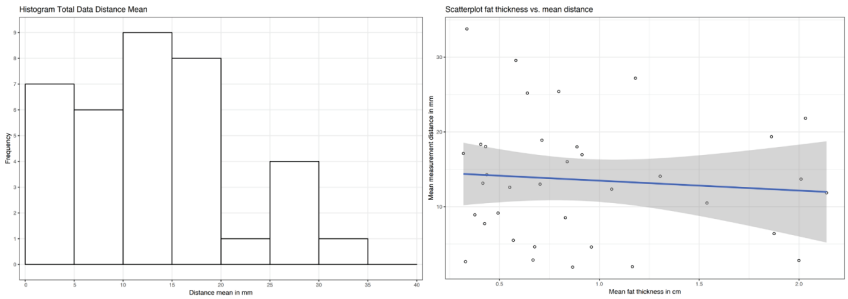

Figure 1: Histogram of the mean distances in mm to the reference points of the total dataset (left) and Scatterplot comparing fat thickness and mean distance. Blue line shows a linear model fitted to the data (using geom_smooth method lm in R). Gray shows the confidence region. (right)

4 Discussion

The BMI and fat thickness above the palpation point does not seem to influence the measurement quality significantly, but they influenced the measurement time. We assume that this effect is less prominent for clinical experts with larger palpation experience. The mean error of 13.5 mm +- 4 mm for each palpation point might be sufficient for the navigation of the US probe in our setting.

5 Conclusion

The reproducibility study showed that palpation is error prone and for our application a careful palpation and location of the anatomical landmarks is crucial. The mean errors are small enough to further evaluate this approach and in a next step we will evaluate the resulting target registration error and the influence on the recorded ultrasound images.

Acknowledgements

We would like to thank our test subjects for the participation in this study.

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