SIFT texture description for understanding breast ultrasound images

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Summary

Texture is a powerful cue for describing structures that show a high degree of similarity in their image intensity patterns. This work describes the use of Self-Invariant Feature Transform (SIFT), both as low-level and high-level descriptors, applied to differentiate the tissues present in breast US images. For such a task, a subset of 16 images has been randomly selected from a larger dataset of 700 Ultra-Sound (US) images acquired at the *UDIAT Diagnostic Centre of Parc Taulí* in Sabadell (Catalunya), between 2010 and 2012. This subset has been complemented with multi-label Ground Truth (GT), as illustrated in figure 1.

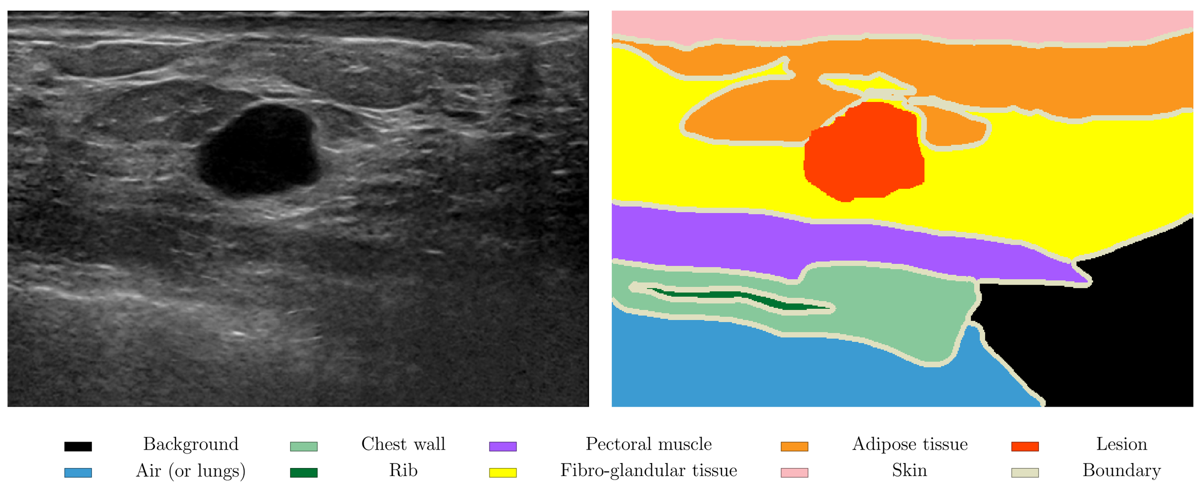

Fig. 1: Data sample: image, accompanying multi-label GT, tissue label GT color-coding.

SIFT as a low-level descriptor, tested using Maximum A Posteriori (MAP)

- Goal: to analyze tissue classes separability based on
  - Bayesian framework for tissue discrimination (see eq. 1).
  - low-level descriptors based on SIFT

$$P(\omega|\bar{x}) = \frac{P(\bar{x}|\omega) \cdot P(\omega)}{P(\bar{x})} \qquad (1)$$

- Feature Description.
  - Extract SIFT descriptors at all pixel positions.
  - Project the 128D SIFT to 2D using Principal Component Analysis (PCA).

- Qualitative analysis can be found in fig. 2,3 and 4.
- Quantitative analysis can be found in fig. 5, where a comparison with intensity feature can be found. The overall sensitivity for the intensity case is $16.6 \pm 27.5\%$, whereas for the SIFT case is $18.8 \pm 17.2\%$ which shows that both feature spaces produce similar results.

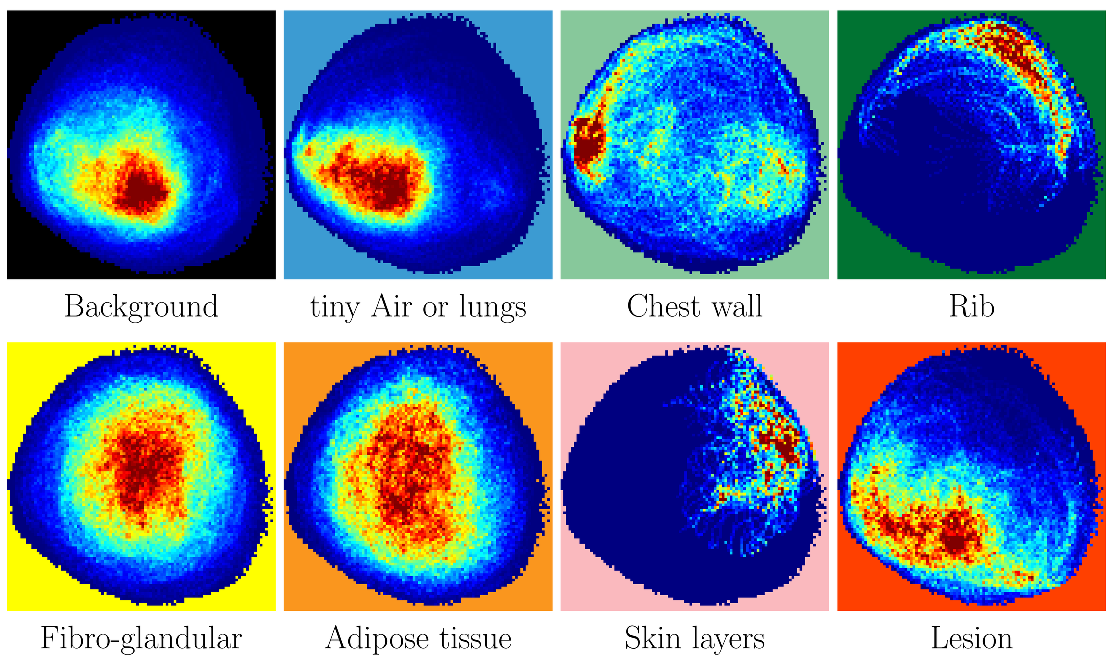

Fig. 2: Distribution of the SIFT descriptors for some classes in the GT.

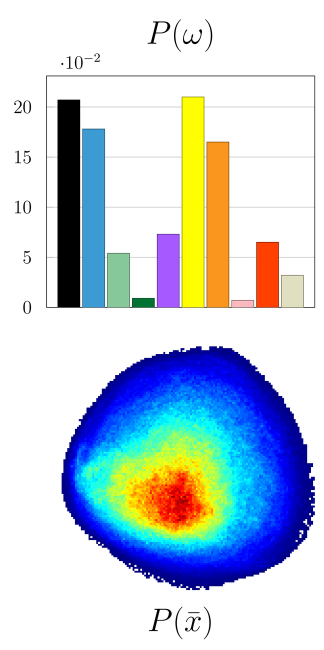

Fig. 3: Data prior knowledge.

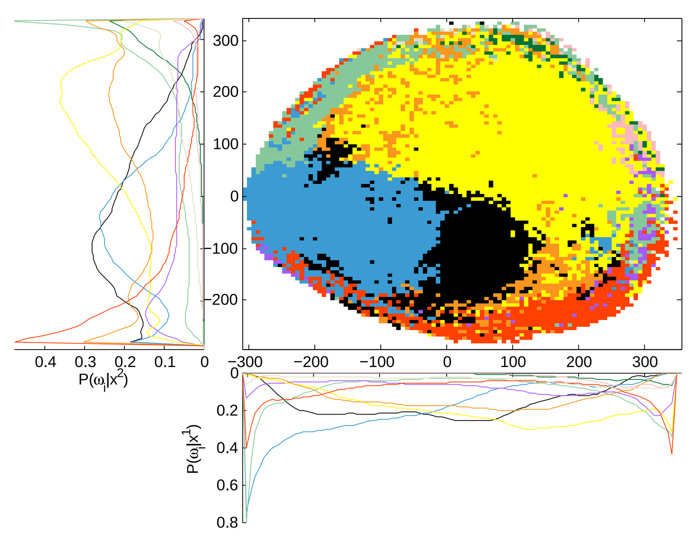

Fig. 4: Qualitative evaluation of the MAP labeling of the feature space.

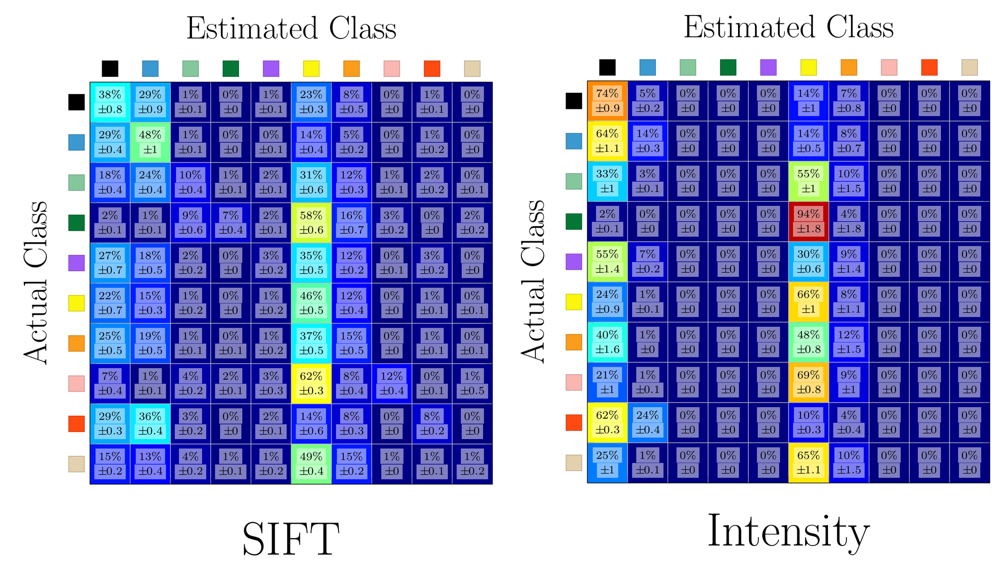

Fig. 5: Confusion matrix showing quantitative results obtained from (10.000 samples × 10 classes) × 5-fold cross-validation.

SIFT as a high-level descriptor using Bag-of-Features (BoF), tested using Radial Basis Function (RBF)-Support Vector Machine (SVM) classifier

- Goal: to analyze tissue classes separability based on
  - Classification framework for tissue discrimination (RBF-SVM).
  - High-level descriptors based on BoF-SIFT.

- Feature Description (see fig. 6).
  - Generate a codebook of the features (k-means, $k = 36$).
  - Extract superpixels (Quick-Shift (QS)).
  - Occurrence study to describe each superpixel.

- Quantitative analysis can be found in fig. 7, The sensitivity achieved is $29 \pm 3.6\%$ for the intensity and $33.5 \pm 2.3\%$ for SIFT.

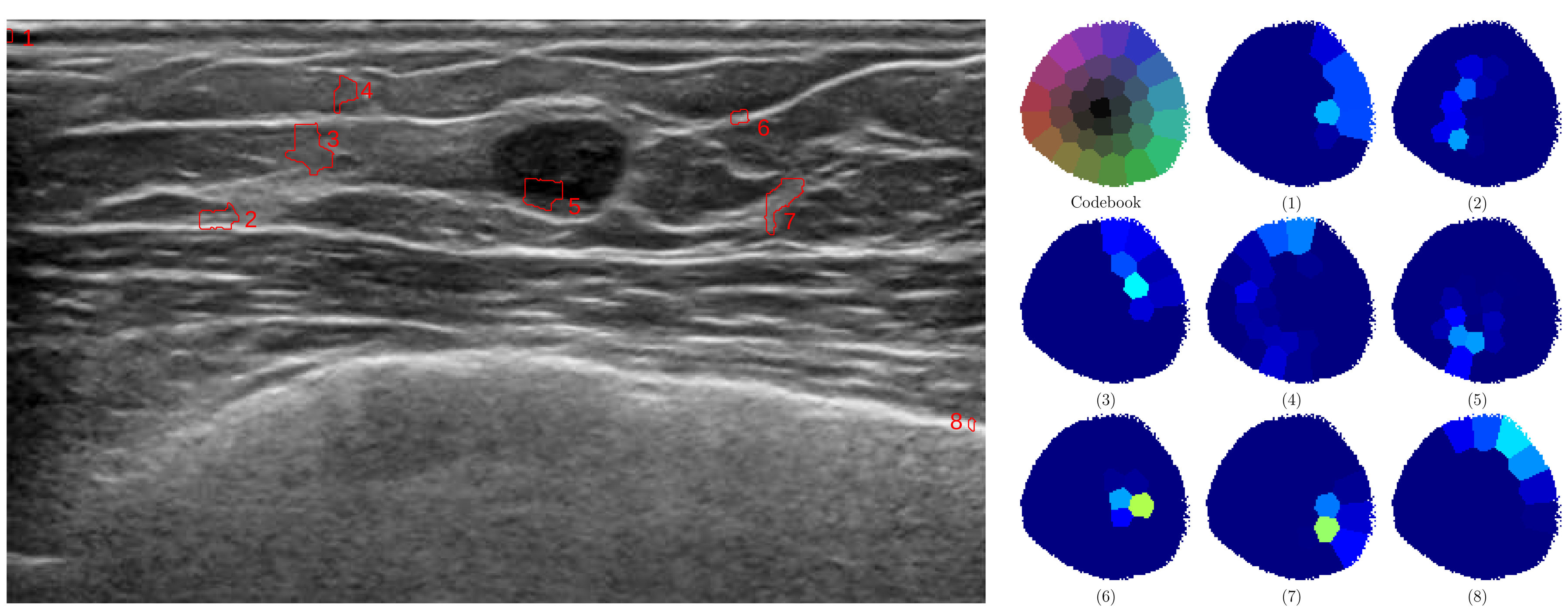

Fig. 6: SIFT-BoF descriptors qualitative analysis. Image example; dictionary example; dictionary occurrence associated with the highlighted superpixels.

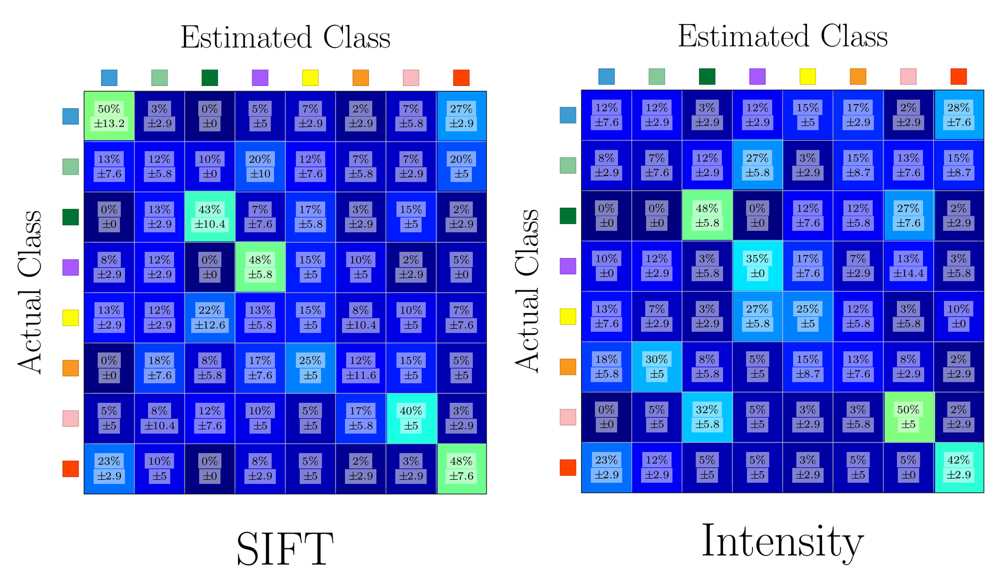

Fig. 7: Confusion matrix showing quantitative results obtained from (1 samples × 8 classes × 3 codebooks) × 20-fold cross-validation.

Conclusion

The present study was designed to explore the usage of SIFT feature space as a texture for characterizing the different tissues present in a breast US image. The usage of SIFT either as a low-level or high-level texture descriptor has been evaluated in comparison to intensity features, which are the features most commonly used. The fact that SIFT and intensity descriptors produce similar results, encourages further studies on using SIFT texture descriptors characterizing breast tissues in US images.

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