SIFT texture description for understanding breast ultrasound images

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Abstract

Texture is a powerful cue for describing structures that show a high degree of similarity in their image intensity patterns. This paper 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.
Experimental results are provided showing the validity of the proposed approach for describing the tissues in breast US images.

Fig. 1: Dataset sample. From left to right: image sample, accompanying multi-label GT, tissue label GT color-coding.

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

In this experiment, it has been analyzed how separable are the tissue classes present in breast ultrasound images, when using low-level descriptors based on SIFT to encode US texture. Here a Bayesian framework has been assumed to perform the tissue discrimination and its results are presented both qualitatively (see fig. 2-4) and quantitatively (see fig. 5).
All the pixel positions of all the images are used as a key-point for extracting a SIFT descriptor and mapped in the $128D$ feature space of SIFT. This SIFT space is then projected into a $2D$ space to visually assess how the tissue classes are distributed in such space. From this projected space, models (see fig. 2) and priors (see fig. 3) are extracted to infer the MAP probability. Figure 4 shows this MAP probability illustrating how the tissue classes are separated based on the observed data.
In order to generate cross-validated quantitative results, the descriptors have been randomly sampled as follows: $(10.000 \text{ samples} \times 10 \text{ classes}) \times 5$ folds. At each round 4 folds have been used for training the models and the remaining fold has been used for testing. Figure 5 shows the corss-validated confusion matrix resulting from classifying breast tissues based on a Bayesian framework using either low-level SIFT texture descriptors or intensity.

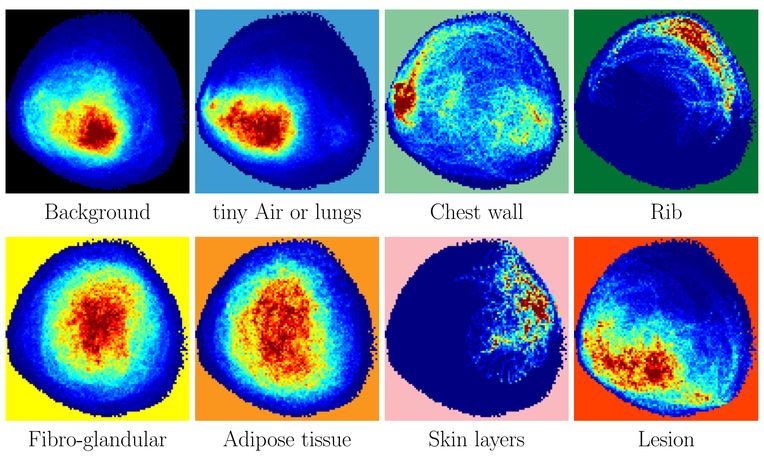

Fig. 2: Distribution of the SIFT descriptors for some classes in the GT.

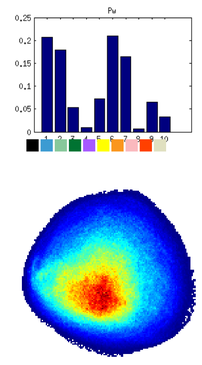

Fig. 3: SIFT space. (a) Projected space colored according to GT tissue labeling. (b) $P(\bar{x}_a)$. (c) $P(\omega)$.

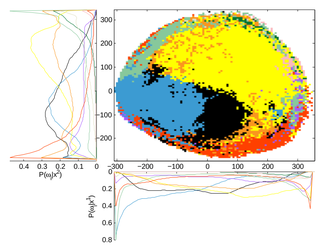

Fig. 4: Qualitative evaluation of the MAP labeling of the feature space.

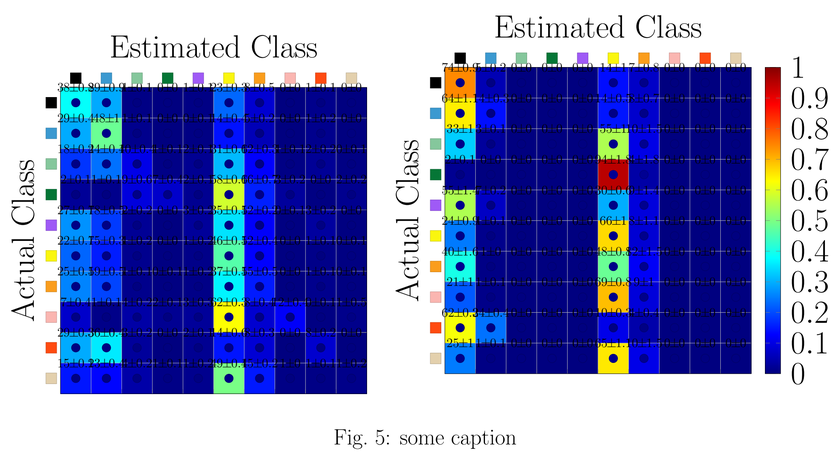

Fig. 5: some caption

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

The high-level texture descriptor is build as a BoF of SIFT descriptors.

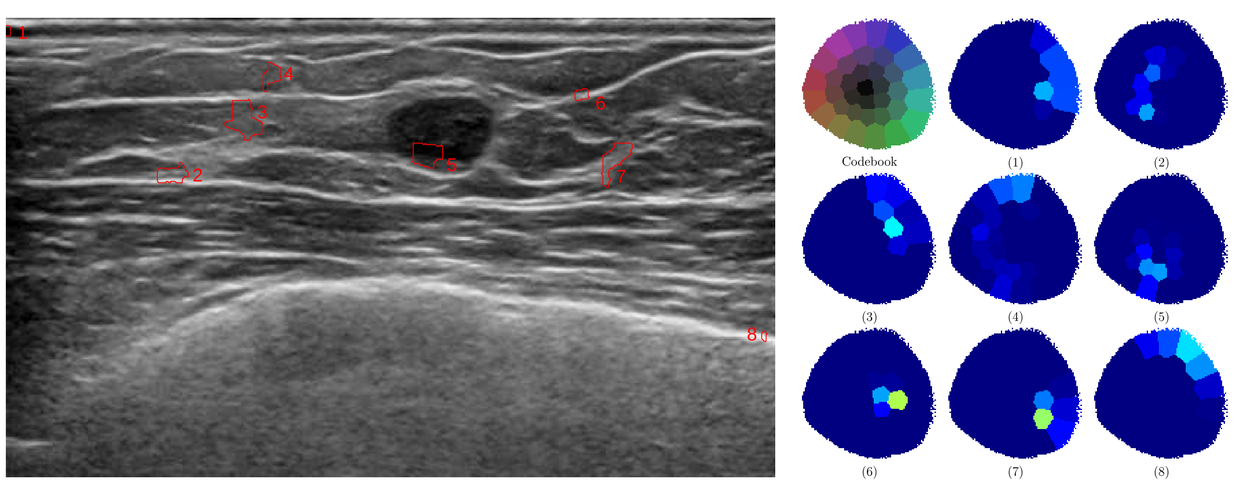

Fig. 6: SIFT-BoF descriptors qualitative analysis. (Left) image example. (Right) Dictionary representation colored using the location of the keypoint location in fig. **??**a space. (1-8) Occurrence of the dictionary's key-points associated to each region highlighted in the original image.

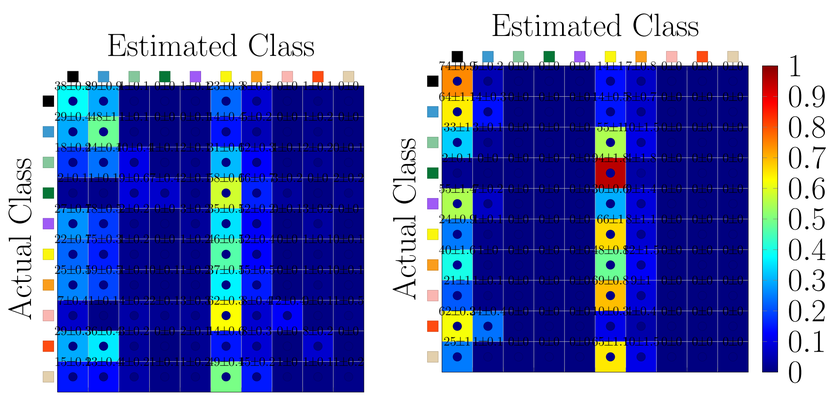

Fig. 7: some caption

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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