Machine learning for accurate differentiation of benign and malignant breast tumors presenting as non-mass enhancement

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Abstract

Accurate methods for breast cancer diagnosis are of capital importance for selection and guidance of treatment and optimal patient outcomes. In dynamic contrast enhancing magnetic resonance imaging (DCE-MRI), the accurate differentiation of benign and malignant breast tumors that present as non-mass enhancing (NME) lesions is challenging, often resulting in unnecessary biopsies. Here we propose a new approach for the accurate diagnosis of such lesions with high resolution DCE-MRI by taking advantage of seven robust classification methods to discriminate between malignant and benign NME lesions using their dynamic curves at the voxel level, and test it in a manually delineated dataset. The tested approaches achieve a diagnostic accuracy up to 94% accuracy, sensitivity of 99 % and specificity of 90% respectively, with superiority of high temporal compared to high spatial resolution sequences.

Data

A set of data from 13 patients with NME undergoing DCE-MRI[1] with two protocols:

- 3T (3D) FLASH T1-weighted MRI Low-temporal high-spatial resolution (LTHSR): pre-contrast, peak, and post-contrast.
- 1.5T (VIBE) T1-weighted MRI Low-spatial high-temporal resolution (LSHTR), 42 measurements.

Preprocessing

- The NME were delineated and visually assessed by expert radiologists following BI-RADS
- All dynamic sequences were registered with SPM to the pre-contrast volume.
- Normalization in intensity by subtracting pre-contrast averaged from the post-contrast images

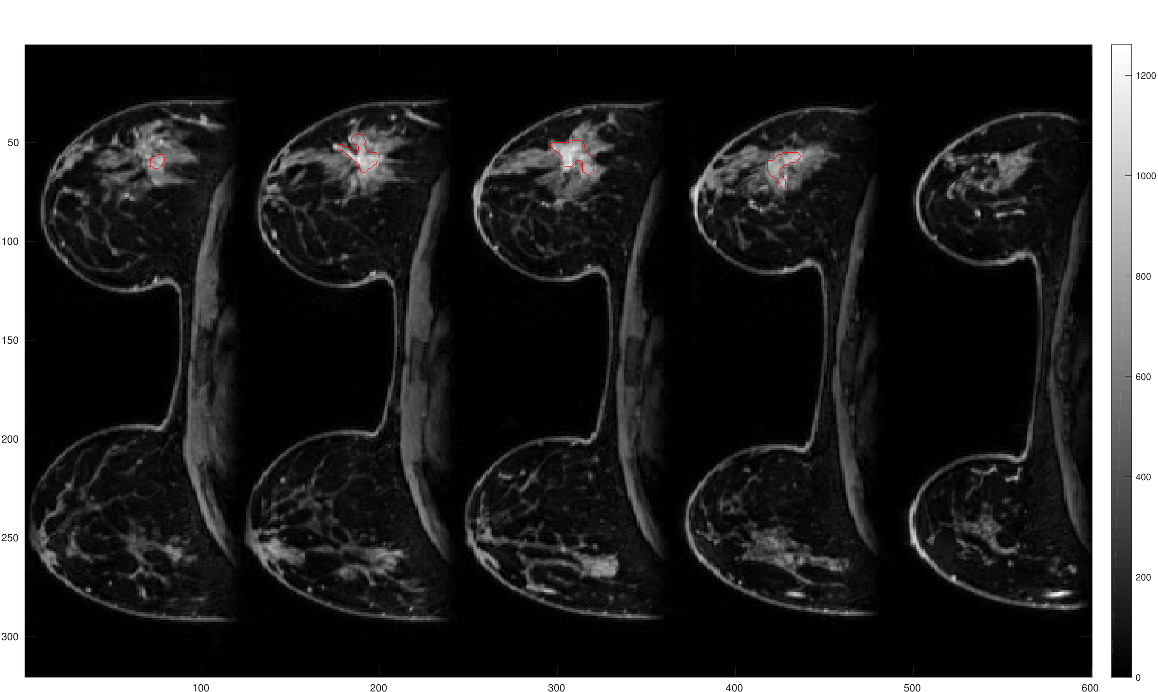


Figure: Representative axial slices of a benign tumor delineated in red.

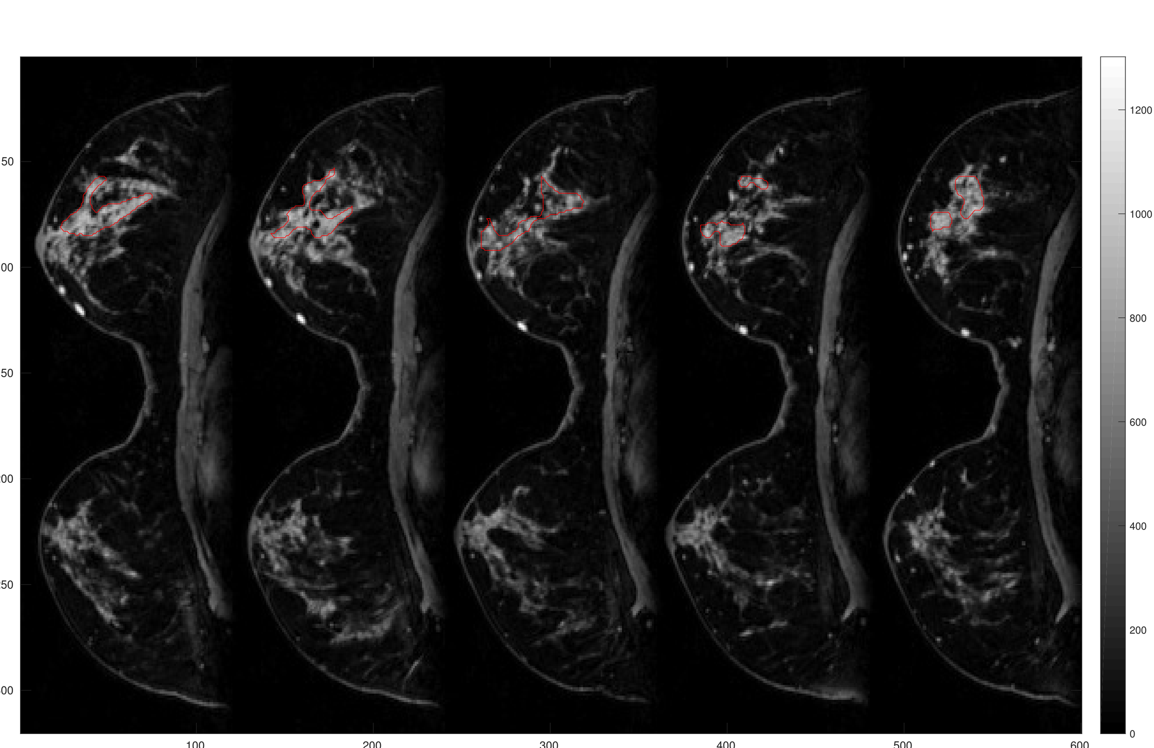
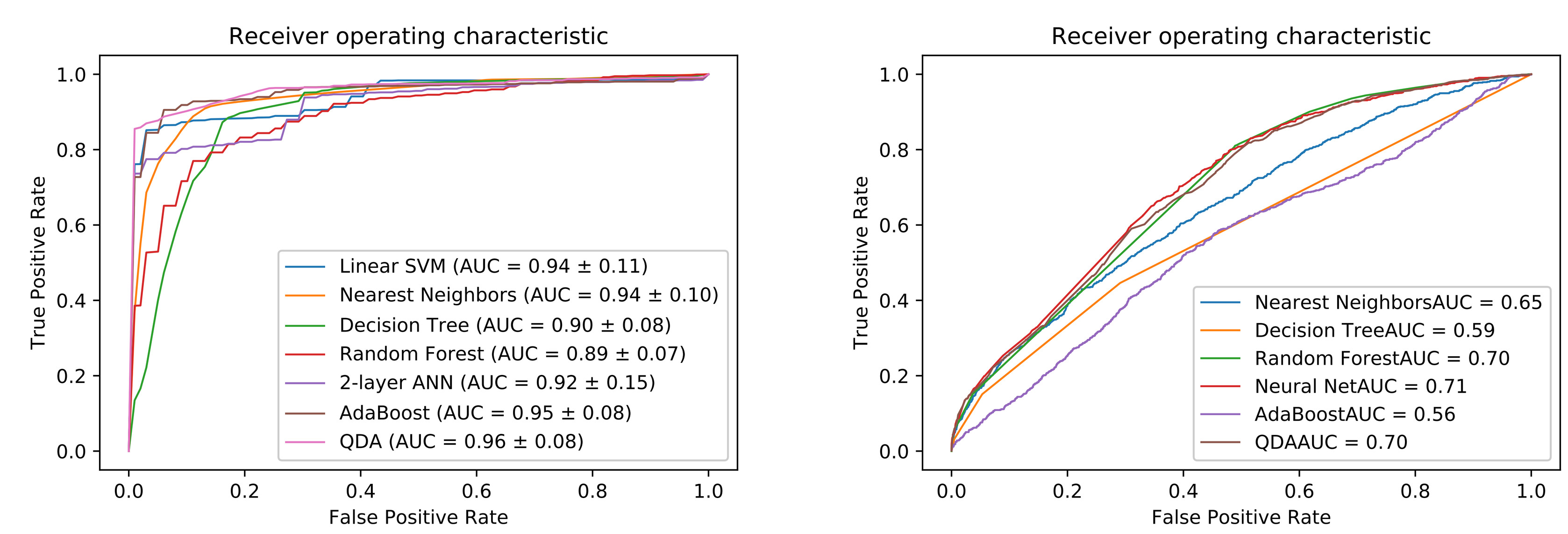


Figure: Representative axial slices of a malignant NME lesion delineated in red.

Results



(a) LSHTR (b) LTHSR

Figure: ROC curve comparison for detection of benign-malignant tissues with various machine learning algorithms.

Table: Performance Parameters for the LSHTR.

	Accuracy	Sensitivity	Specificity	AUC
Linear SVM	**0.94 ± 0.09**	0.98 ± 0.03	0.90 ± 0.18	0.94 ±0.11
Nearest Neighbors	0.92 ± 0.08	0.94 ± 0.04	0.90 ± 0.20	0.94 ± 0.10
Decision Tree	0.91 ± 0.07	0.94 ± 0.03	0.82 ± 0.17	0.90 ± 0.08
Random Forest	0.85 ± 0.03	0.85 ± 0.02	0.84 ± 0.21	0.89 ± 0.07
ANN	0.91 ± 0.12	0.93 ± 0.05	0.91 ± 0.23	0.92 ± 0.15
Adaboost	0.93 ± 0.09	0.95 ± 0.03	**0.90 ± 0.18**	0.95 ± 0.08
QDA	0.93 ± 0.14	**0.99 ± 0.02**	0.89 ± 0.22	**0.96 ± 0.08**

Conclusion

CAD systems for differentiation of benign and malignant breast tumors presenting as NME lesions in DCE-MRI provide tools that aid the radiologist in accurate diagnosis. Here, we employed seven different machine learning approaches to the problem of differentiation between benign and malign NME lesions, by using LSHTR DCE-MRI images, and LTHSR DCE-MRI images. In general, machine learning techniques are successful in differentiating benign from a malignant tumors with a superiority of high temporal compared to a high spatial resolution sequences. Taking into account that the BI-RADS criteria for the lesions studied in this work recommended biopsy for all the lesions, and the malignancy was established histopathologically, the results presented here indicate that using machine learning could facilitate the accurate differentiation of malignant and benign breast tumors, and reduce the number of unnecessary biopsies in breast cancer.

References

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