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Extracting Features from Multistatic Signals in a Radar Microwave Imaging System for Breast Cancer Detection

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Abstract

This paper addresses the process of extracting features from multistatic signals collected during the simulation (or operation) of a radar multistatic microwave imaging system for breast cancer detection. These features are then useful for classification purposes, for example classifying between benign and malignant tumours, or to build a classification-based image of the breast that can help reduce false positive and false negative tumour detections. As a result, such features may be used to monitor and track tumour size development during therapeutic procedures.

1. Introduction

We have previously addressed the use of classification algorithms in both monostatic and multistatic radar microwave imaging systems for breast cancer classification [1-3] and detection [4, 5], respectively. The use of classification for breast cancer detection is of particular interest as this information can be complemented with traditional radar microwave imaging (comprising a skin artifact removal algorithm followed by a beamformer [2]) and help reduce false positive and false negative tumour detections. In particular, a probabilistic map of the breast is made, and classification is used to indicate regions within this map where signals are more likely to correspond to tumours ("hits") and healthy tissue ("misses"). We have published initial work in this area in [4, 5]. In this work, we created a customised feature extraction method so that the most relevant and suitable features of microwave signals can be found in order to help classify a focal point (i.e. voxel) in a breast map as "hit" or "miss".
The remainder of the paper details how some of the implemented 24 features are calculated.

2. Customised Feature Extraction

We have implemented a customised feature extraction algorithm which automatically calculates 27 features which can later be fed to a classifier so it can generate a probability map of breast cancer, following [4, 5]. Our feature extraction algorithm is adapted to work in a radar quasi-multistatic system. For a system with n antennas, a quasi-multistatic system operates in the following way, each antenna – in turns – transmits an ultrawideband signal and all other antennas receive its resulting backscattered signals, meaning that there are n(n-1) recorded signals (S_ij), in which i is the transmitting antenna and j the receiving antenna, and $i \neq j$. Because we reconstruct a probability map of the whole breast profile, we have n(n-1) signals to process to each focal point of the probability map. It is then essential to extract relevant features from our signals before further processing them, otherwise the dimension of our problem is too large and the probabilistic map of the breast may be too slow to reconstruct. Features can be extracted from multistatic signals individually (section A below) and from the summed signal of all multistatic signals (section B below), for a single focal point in the probabilistic map.

2.1. Features from single signals

1. Mean of the variance of each signal;
2. Mean of the standard deviation of each signal;
3. Variance of the global maximums amplitudes;
4. Variance of the global maximums indices;
5. Variance of the global minimums amplitudes;
6. Variance of the global minimums indices;
7. Standard deviation of global maximums amplitudes;
8. Standard deviation of global maximums indices;
9. Standard deviation of global minimums amplitudes;
10. Standard deviation of global minimums indices.

2.2. Features from summed signals

11. Number of local maximums;
12. Average amplitude of local maximums;
13. Average distance between local maximums;
14. Amplitude of the global maximum;
15. Index of the global maximum;
16. Number of local minimums;
17. Average amplitude of local minimums;
18. Average distance between local minimums;
19. Amplitude of the global minimum;
20. Index of the global minimum;
21. Absolute area under the curve: sum of amplitude absolute values of the signal;
22. Area under the curve in percentage: sum of the amplitude values of the signal divided by absolute area under the curve;

23. Percentage of positive area under the curve;
24. Percentage of negative area under the curve;
25. N
26. Variance;
27. Standard deviation.

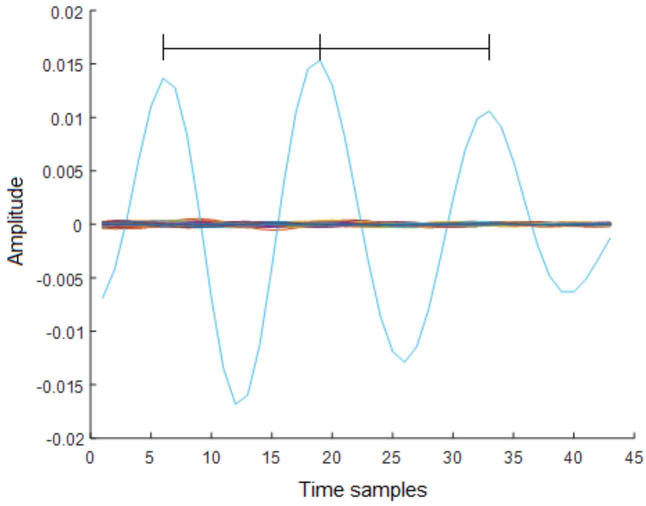

Figure 1. Individual multistatic signals around the zero baseline, and summed signal for a "hit" focal point in blue. F11 (Number of local maximums) would be 3 in this example, and F13 (Average distance between local maximums) would be 13.5. Y axis has no units as all summed signals had been previously normalised.

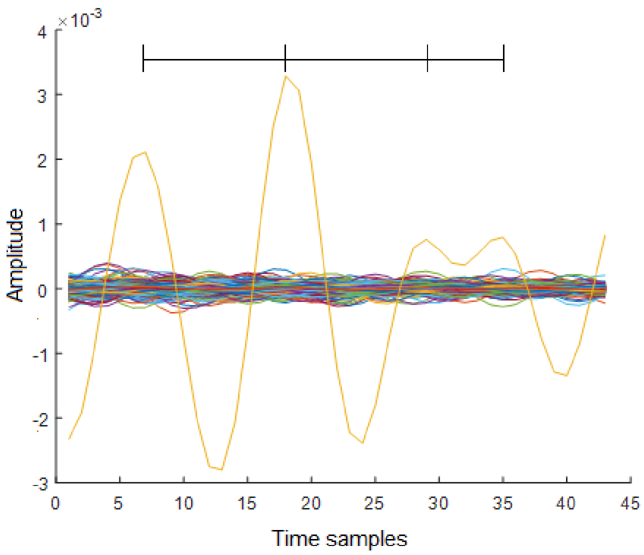

Figure 2. Individual multistatic signals around the zero baseline, and summed signal for a "miss" focal point in blue (to note that the amplitude of these signals is significantly lower than a "hit" focal point, e.g. Fig. 1). F11 (Number of local maximums) would be 4 in this example, and F13 (Average distance between local maximums) would be 9.33.

2.3. Examples of extracted features

The following figures illustrate some of the extracted features presented above. F11 and F13 are illustrated in Fig. 1 and Fig. 2, F22 is illustrated in Fig. 3 and Fig.4.

3. Conclusions

We presented a customised feature extraction methodology which can be used to extract relevant information from multistatic radar microwave imaging systems. Future work will include extending this methodology to operate in monostatic radar microwave imaging systems and to make an optimization of which features yield better classification results (i.e. perform feature selection).

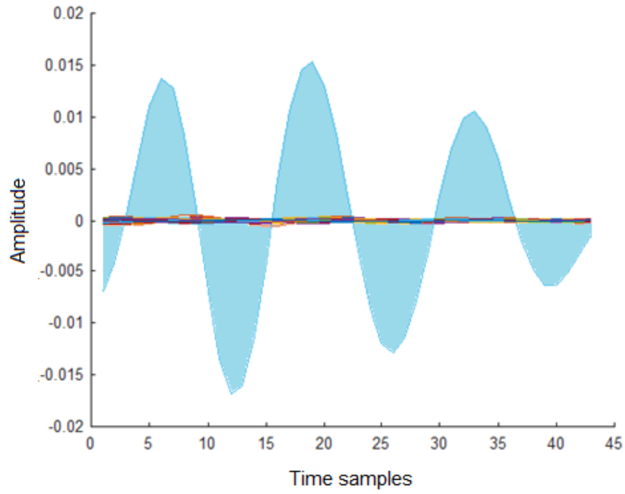

Figure 3. Individual multistatic signals around the zero baseline, and summed signal for a "hit" focal point in blue. F21 (Absolute area under the curve: sum of amplitude absolute values of the signal) is the area marked in light blue in this example.

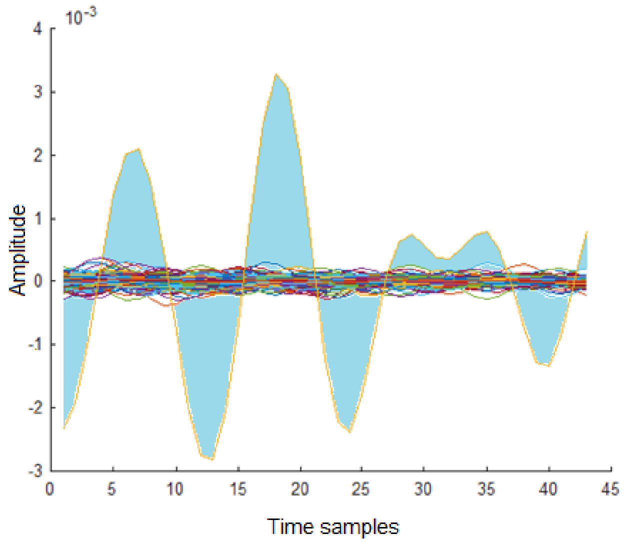

Figure 4. Individual multistatic signals around the zero baseline, and summed signal for a "miss" focal point in blue. F22 (Absolute area under the curve: sum of amplitude

absolute values of the signal) is the area marked in light blue in this example.

4. Acknowledgements

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5. References

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