

Fig. 2. Receiver operating Characteristics for the array and single channel detectors.

Channel 1 data and the array data give comparable detection performance. However, if we had known the signal (and applied the test of Eq. (3)), the performance of the Array detection would have been much better due to its higher equivalent SNR. Thus, we can conclude that the performance gain in array detection is more pronounced in the case of known and unknown signals equally likely.

We ran Monte Carlo simulations for detection of unknown spikes for single channel and array observations. The performance of spike detection in the time domain and multiresolution (wavelet) domain is compared. Fig.3 shows the performance of detection for single channel detection in multiresolution and time domain for an SNR of 7.6024. As we can see, the multiresolution detection performs much better than the time domain detection. Fig.4 shows an ROC curve for multiresolution and time domain detection of an unknown signal in a two channel array at an SNR of 8.117. At these noise levels, the spikes are well masked by the noise so as to make detection by visual inspection quite difficult.

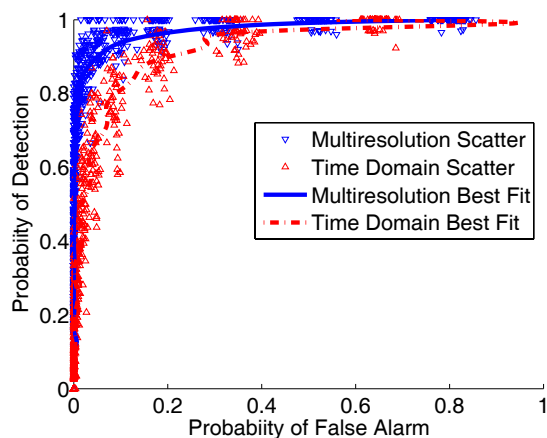


Fig. 3. ROC curves for the single channel detector at an SNR of 7.6024.

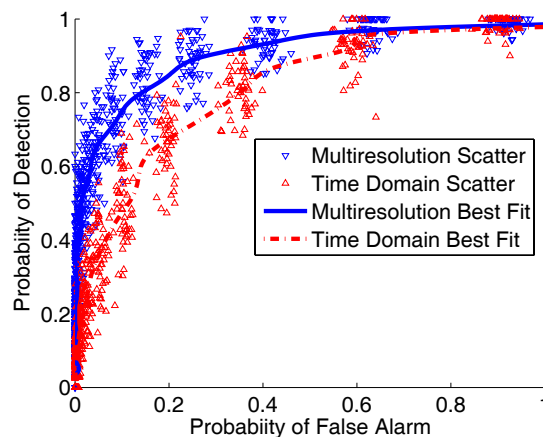


Fig. 4. ROC curves for the single channel detector at an SNR of 8.1177.

VI. CONCLUSIONS

We have derived Bayesian tests for spike detection in the single electrode and array cases. Analytical results for the Receiver Operating Characteristics have been obtained for the known and unknown signal cases. Detection using the multielectrode array data gives remarkably better performance than single channel spike detection. A Uniformly Most Powerful property for the array detection versus the single channel detection was derived for the known signal case in terms of an “equivalent array SNR”. The effect of the spatial correlation of the noise on the performance of the array detection was also investigated. In the case of an unknown signal case, the array detection gives better performance than the single channel detection for certain signal and noise cases, but it may not be Uniformly Most Powerful. We have focussed our attention on the unknown signal case, as spike detection takes place before any signal parameters are estimated. Representing the data in a multiresolution domain and running the tests on various time scales improves detection because the wavelet compresses the signal energy in a much smaller number of coefficients. The performance gain in wavelet domain detection has been experimentally verified for various Signal to Noise Ratio conditions in single channel and array cases.

REFERENCES

- [1] K.D Wise, D.J. Anderson, J.F. Hetke, D.R. Kipke, and K. Najafi. Wireless implantable microsystems: High-density electronic interfaces to the nervous system. In *Proc. of the IEEE*, volume 92, pages 76–97, 2004.
- [2] D. J. Johnson and D.E. Dudgeon. *Array Signal Processing*. Simon and Schuster, 1992.
- [3] K. G. Oweiss. *Multiresolution Analysis of Multichannel Neural Recordings in the Context of Signal Detection, Estimation, Classification and Noise Suppression*. PhD thesis, Univ. of Michigan, 2002.
- [4] K. G. Oweiss and D. J. Anderson. A multiresolution generalized maximum likelihood approach for the detection of unknown transient multichannel signals in colored noise with unknown covariance. In *Proc. of ICASSP'2002*, volume 3, pages 2993–2996, May 2002.
- [5] Z. Nenadic and J. W. Burdick. Spike detection using the continuous wavelet transform. *IEEE Trans. Biomed. Eng.*, 52(1):74–87, Jan. 2005.
- [6] S. Mallat. *A Wavelet Tour of Signal Processing*. Academic Publishers, 2 edition, 1999.