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FFT based Spectrum Sensing over Rayleigh Frequency Selective Fading Channel in In-band SIMO Full-Duplex CRNs

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This paper presents fast Fourier transform (FFT) based multiband spectrum sensing over multipath Rayleigh frequency selective fading channel for single input multiple output (SIMO) full duplex (FD) cognitive radio networks (CRNs) under residual self-interference (RSI) that affirms a more realistic scenario in heterogeneous networks for future wireless applications. In in-band FD mode, secondary users (SUs) can sense and transmit simultaneously using the same channel, doubling the spectrum efficiency of the FD enabled CRNs [1]. Researchers have extensively worked on multiband spectrum sensing in single input single output half-duplex CRNs under additive white Gaussian noise scenario [2], but fading environment is another limiting factor that results in additional detection performance degradation. In this work, we address this issue and carried out the evaluations under multipath fading scenario and to alleviate the degradation in detection performance due to fading, we use multiple antennas at SU. The SIMO sensing architecture of the proposed energy detector is shown in Fig. 1. The Proposed sensing algorithm first calculates the energy of the received k^{th} subband of m^{th} orthogonal-frequency-division-multiplexing (OFDM) symbol. Next, two dimensional windowing operation followed by hypothesis detection of the presence and absence of PU signal is performed on the calculated energy value. The block schematic diagram of the proposed ED is shown in Fig. 2, in which LRT statistic could be formed as:

$$T(Y[m,k]) = \frac{1}{N_r} \sum_{n_r=1}^{n_r=N_r} \frac{1}{N_f} \sum_{k=k_0-N_f/2}^{k_0+N_f/2-1} \frac{1}{N_t} \sum_{m=n_0-N_t+1}^{m_0} |Y[m,k]|^2 \geq \gamma \tag{1}$$

where, $Y[m,k]$ is the received signal at k^{th} subcarrier of m^{th} OFDM symbol. N_r is the number of receive antennas at SU. N_t and N_f are filter lengths in time and frequency dimensions respectively and γ is the threshold value determined by the fixed false alarm probability (P_{fa}) which is given as: $P_{fa} = Q\left(\gamma - (\sigma^2(1+INR)/\sigma^2\sqrt{\frac{2(1+INR^2)}{N_r N_t N_f}}\right)$. Here, σ represents the noise variance at k_{th} subband and INR is the RSI power to noise power ratio.

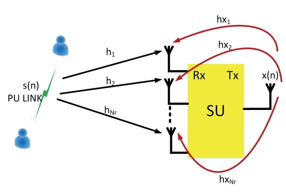

Figure 1. SIMO sensing architecture

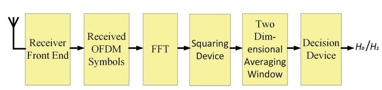

Figure 2. Block schematic of proposed ED

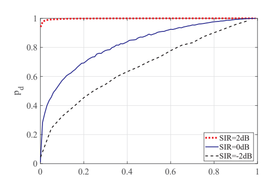

Figure 3. P_d vs P_{fa} for different SIR

The performance evaluation of the proposed algorithm through MATLAB simulation is depicted in Fig. 3, which show probability of detection (P_d) vs P_{fa} plot for different values of SIR with $N_t = 11$ and $N_f = 4$ performance under RSI in SIMO FD-CRN. The parameters considered are signal-to-noise ratio (SNR), signal-to-interference ratio (SIR), INR, N_r, N_t and N_f. Fig. 3 clearly shows degradation in detection performance with decrease in SIR, which affirms increase in RSI. Finally, it is inferred that, target detection probability $(P_d \geq 0.95)$ could be achieved with $P_{fa} = 0.1$, $N_t = 11$ and $N_f = 4$ at $SIR = 2\ dB$ validating the applicability of the proposed sensing algorithm in SIMO FD CRNs. The detection performance could be further improved by employing efficient SI cancellation techniques and the work could be further extended in MIMO FD CRNs in future.

References

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