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Cooperative Spectrum Sensing with Ternary Local Decisions

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Cognitive radio has recently emerged as a promising solution for the current spectrum shortage by allowing the unlicensed secondary users to re-utilize the spectrum temporarily released by the licensed primary users. The first and foremost function in cognitive radio is spectrum sensing. Due to the fading effect, the signal strength received at individual secondary users can be very low. In order to improve sensing performance, cooperation among secondary users is typically employed, where multiple secondary users simultaneously sense the primary user?s presence and forward their local information to a fusion center that henceforth makes a global decision. Due to the bandwidth limitation, only finite amount of information can be passed from the local secondary users to the fusion center. For simplicity, most cooperative spectrum sensing designs only consider the case of single-bit local decision, where each secondary user only sends a 1-bit message to the fusion center. However, some system setups may allow for multi-bit information forwarding from the cooperative secondary users to the fusion center for an improved sensing performance.

As a transition to cooperative spectrum sensing with multi-bit local decisions, this paper considers the ternary case. Although this has been studied in several previous works in the literature, neither closed-form sensing strategies nor quantitative performance gains have been obtained. In addition, they are usually dependent on high-complexity numerical optimization. In this paper, low-complexity local and fusion rules are developed for ternary cooperative spectrum sensing and the performance gains are illustrated and quantified in terms of the diversity and signal-to-noise ratio (SNR) gain.

Starting with a brief review on the cooperative diversity of spectrum sensing and basic binary cooperative spectrum sensing strategies, this paper makes a side-by-side comparison between binary and ternary sensing in terms of the local probabilities and the fusion decision regions. Accordingly, by reducing the dimension of the fusion decision statistics, a link is established between the ternary and binary cooperative spectrum sensing. Then, a set of low-complexity closed-form local decision thresholds is found to facilitate the ternary fusion rule design. Aiming at achieving the maximum SNR gain while maintaining high diversity orders, the optimal decision region is derived for ternary cooperative spectrum sensing. Compared with binary sensing, it is shown that both diversity and SNR gain can be achieved with ternary sensing. In summary, this paper uses binary sensing as a baseline to design a low-complexity ternary sensing strategy with

diversity as the performance measure. Readers who are interested in practical cooperative sensing designs under a given reporting channel bandwidth constraint would find this paper very insightful.

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