Machine Learning Techniques for improving Spectrum Sensing in Satellite Communication System: Review

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***Abstract*: Several spectrum sensing detection strategies have been proposed in recent years, including special range detection calculations based on the maximum a posterior (MAP) rule, energy detection, and others. Spectrum sensing plays an important role in enabling cognitive radio (CR) technologies for the next generation of wireless communication systems. All of these methods require setting thresholds, as well as prior knowledge of the noise distribution. Cooperative spectrum sensing is used to improve the sensing performance. When GEO (geostationary) and NGEO (non-geostationary) resultant systems coexist on the same recurrence, the non-geostationary system should not create a harmful barrier to the GEO. Several sensing methods have been proposed in recent years, including specific spectrum sensing algorithms based on the maximum a posterior (MAP) rule, energy detection, and others. The machine learning calculations in this paper are the most advanced for spectrum detection. With 2000 dataset measurements, we can also calculate location probability, false alarm probability, response time, miss detection, throughput and accuracy.**

Keywords: Terms such as the Maximum a posteriori (MAP), higher order moments (HOM), hypothesis testing, false alarm probability, and probability of detection have been used to describe spectrum sensing and cognitive satellite communication.

I.INTRODUCTION

The absence of a dedicated frequency spectrum for radio communications has prompted researchers to look for solutions that can mitigate the problem by adjusting transmission to changing spectrum sensing and network usage patterns. The most promising of these technologies, cognitive radio, has the potential to reduce interference caused by spectrum coalescence while improving spectrum usage. Spectrum awareness allows the cognitive system to become aware of empty and unused bands with the aim of sparing them, which is the main objective of this strategy [1].

It has been observed from the studies of the past years that spectrum sensing methods have been introduced to identify the primary user (PU) signals for cognitive radio satellite communication. In the face of noise unpredictability, as in the operation of cognitive radio satellites, the energy detection method dramatically reduces its efficiency at low signals compared to the noise ratio method. Recently higher-order-moment based spectrum sensing approaches have been developed to overcome the energy detector inadequacies in the event of noise unpredictability while reducing the computing complexity of the system. Many other traditional spectrum sensing methods detect signals using cyclo-stationary method. We provide the first (to the authors knowledge) higher-order-moment based spectrum sensing algorithm for cognitive radio satellite communication, which is capable of the fastest and most reliable detection of GEO (principal user) signals. These approaches indicate that in the presence of noise unpredictability, the method outperforms both the method and the standard energy detector, with a slight increase in computing cost.

In this context, spectrum sensing is commonly used as a potential alternative. With the increasing number of non-geostationary satellites in orbit, one geostationary system can be influenced by another non-geostationary. When this GEO system detects the signal, in that case the GEO primary user is the non-geostationary secondary user, and another non-geostationary user intervention occurs. In this approach, we present a spectrum technique based on hypothesis testing and posterior maximum to separate signals from noise and determine the power level of the GEO system.

Much attention has been paid to cognitive radio as a potential solution to spectrum constraints. Spectrum sensing allows the discovery of less used licensed frequency bands, as well as the opportunistic use of such bands by unlicensed users, resulting in increased spectrum implementation. A geostationary orbit satellite and a pair of low earth orbit satellites share the spectrum for the space information network, in which low earth orbit spectrum sensing is used to understand GEO spectrum occupancy conditions and low earth orbit data transmission. Earth orbit spectrum sensing allowed the satellite to access the shared spectrums of the GEO. A spectrum sharing architecture based on two phases is designed to boost the efficiency of data transmission by transferring low-earth orbit satellite data in both low-earth-orbit overlay and underlay modes, in contrast to traditional spectrum sharing techniques [5]-[8].

In overlaying mode, data transmission from low earth orbit can execute transmission at any required transmit power. In contrast, a spectrum sensing and power allocation aided spectrum sharing (SPA-SS) strategy in underlay mode is suggested to ensure that data transmission from low earth orbit causes minimal disturbance to the GEO. To be more precise, the sensing orbit in the spectrum of the first stage is used to sense the low earth spectrum. The time interval is carefully optimized to minimize interference received in the GEO in the second phase. In addition, Phase II has developed an adaptive power allocation to maximize the throughput of data transmission from low earth orbit while minimizing interference to the GEO within tolerable interference temperatures.

II. LITERATURE REVIEW

Table 1. Literature Review

Author	Journal	Work	Outcome
Chi Zhang et al. [3]	IEEE Transaction Vehicular Technology	In spectrum method both MAP rule and hypothesis test are used.	Traditional sensing methods are outperformed by hypothesis testing and MAP rules.
Francesco Benedetto et al. [2]	IEEE [2020]	Higher Order Moments are used in a new spectrum sensing technology for cognitive satellite communication.	HOM-based range detection procedures are designed to address the issue of finding vitality under vulnerabilities while generating very little profiling complexity.
Chun xiao Jiang et al. [4]	IEEE [2019]	Special Sensing Algorithms and a MAP rule-based spectrum sensing approach.	Both satellite GEO and NGEO systems use a variety of transmit power levels to accommodate both the actual transmission and the theoretical demand for transmitting power optimization.
Yun feng Wang et al. [5]	IEEE [2020]	Spectrum-sensing and power-allocation assisted spectrum-sharing (SPA-SS) calculations can be a spectrum-sensitive and power-allocation assisted spectrum-sharing strategy.	The SPA-SS (spectrum-sensing and control assignment helped spectrum-sharing) strategy goes beyond the classic spectrum-sharing method.

Chi Zhang et al. [3] presented as the number of NGEO satellites in space evolves, the NGEO infrastructure may be influenced by other interference NGEO structures, particularly the recognition of signals by the GEO framework. In this work, the range detection approach for the coexistence between GEO and NGEO framework is explored. We propose a traceable range detection process for the NGEO framework. We propose a range detection process for the NGEO framework to reach the GEO range, taking into account the different transmission control levels of both satellites depending on the probability. Uplink and downlink are two ways of communicating satellite communication signals. If GEO is present, the final step is to identify its power level according to the motion of the interfering NGEO satellites when establishing the GEO power level, with the first emphasis being on isolating GEO signal from the interfering NGEO satellite. Hypothesis testing and MAP rule specific sensing methods are used. The detection in this research is based on the MAP rule. When the SNR or sample length is increased, the detection probability and false alarm probability performance are improved. We use the closed frame for edge expression and the choice region in the downlink where to identify the proximity of the GEO structure and then to initiate the range process to isolate specific control levels until the GEO structure is disrupted. NGEO detection was broadcast with very little control or no control at all. (e-mail: meganzc@163.com).

Francesco Benedetto et al. [2] proposed as an innovative spectrum sensing approach to cognitive satellite communication that identifies a primary user signal and employs a unique spectrum sensing method. Firstly, the usable signal power is determined from the noisy received signal, by integrating the second and fourth order moments of the data under question. Second, the probability of occurrence of an interesting signal is indicated, using the above usable power as the choice variable. As a result of this finding, the suggested approach has higher detection efficiencies and shorter sensing time than conventional detectors. This is particularly effective for cognitive satellite communications.
(emails: Francesco.benedetto@umiroma3.it, gaetano. Giunta @ uniroma3.it, luca.pallotta@uniroma3.it).

Chun xiao Jiang et al. [4] gives when a GEO system is issued, one NGEO system belongs to the SUs, and the other NGEO system is the intervening user in the event of coexistence. The process and calculation of conditional detection proposed in this idea works when the GEO framework is actually dealing with transferred control levels. We accept that the normal control level of the GEO is a stable control level, because the conditional range detection method requires the discharge to operate continuously at the control level. We used a hypothesis-testing technique with a one-point expression of additional conditional identity calculations. Due to a displayed wilderness, the range of routine detection involves a performance misfortune compared to our procedure. Furthermore, both the GEO and NGEO frameworks are assumed to operate with different communication control levels that add hypothetical prerequisites for transmission control adjustments compared to the actual transmission. (e-mail:meganzc@163.com,{jchx,jinjin_sat,thuray,kll}@tsinghua.edu.cn).

Yun feng Wang et al. [5] presented a pair of GEO satellites and low earth orbit satellites are used to sense the spectrum occupancy position of a GEO satellite and allow access to shared GEO data with the help of spectrum-sensitive low earth orbit satellites. We have specifically examined the effect of high mobility of low-earth-orbit satellites on spectrum sharing. An SPA-SS method has been introduced once again to boost the throughput of data transmission by a low-earth orbit satellite. Simultaneously optimize the spectrum sensing time, sensing interval and communication power of a low earth orbit system to maximize the throughput of a low earth orbit system in an interference region. Meanwhile, the objective is to meet the power restriction of the spectrum-sensing low-earth orbit system while remaining within the rate constraint of the GEO system. According to simulation findings the suggested algorithm can protect GEO systems while achieving higher low-earth orbit system throughput than existing spectrum sharing strategies. In future work, we suggest spectrum sharing system under the effect of satellite disturbances between several low-earth orbit satellites and the GEO system, which includes a large group of low earth orbit satellites as well as the GEO system. (e-mail: Xiaoxia Ding (dxj@njupt.edu.cn)).

III. COMPARISION

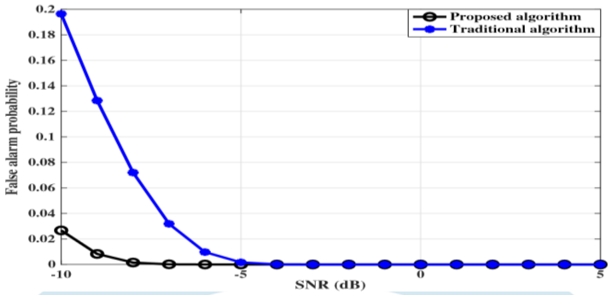

Fig.1.Traditional range detection includes a false alarm rate of 5000 within downlink, compared to the recommended method.

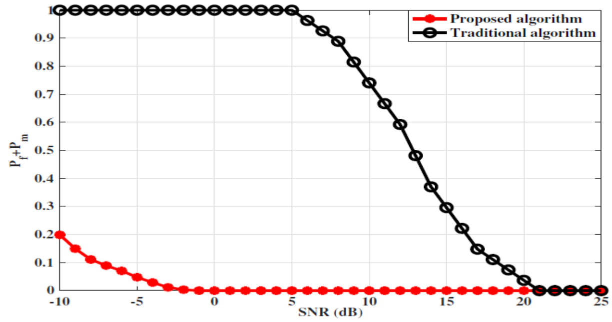

Fig.2.The number of tests in the downlink is 3000, classical range detection outperforms the recommended approach.

The GEO framework is actually dealing with different control levels. We accept that the GEO normal control level is stable as the major user operates at a stable control level within the standard double detection approach. As shown in Fig.1, there are 5000 trials in total. Compared to our strategy, the traditional spectrum detection involved a punishment of execution due to consistent performance. The conditional range detection approach assumes that the vital user operates at a stable control level, and we accept that the general control level of the GEO remains consistent. When the number of trials is 3000, we assess the performance of the two segmentation procedures in terms of the probability of misalignment and missed detection, as shown in Fig.2. Compared to our approach the traditional spectrum sensing model suffers from mismatches. The goal of this section is to assess the performance of FOM, a proposed method for spectrum sensing in satellite communication systems. The GEO satellite will transmit at a power level chosen from a predetermined set of three levels as shown in the downlink scenario in [4]. To conclude our research of the recommended detector for satellite spectrum sensing, we calculate the mean detection time (MDT) required to detect a GEO signal. DLEO system time is shown against use angle when angle separation refers to a fixed power DLETO system that will stop operating when the interference limit of the GEO system is reached [10]-[11]. This reference indicates that both systems can communicate properly and comply with applicable ITU-R requirements.

IV. CONCLUSIONS

Prior research has shown that there are continuous efforts to improve spectrum sensing technology. Using a similar strategy, we can improve our findings by introducing cooperative detection. The range detection approach has been explored for the coexistence between GEO and NGEO framework. Hypothesis testing and MAP rule specific sensing methods have been used. Another new spectrum-sensing technology with high detection probability and short sensing time is the classic detector, which has proven to be highly useful for cognitive satellite communications. When large-scale satellites become more widely deployed, we will adopt the method suggested in future work to share spectrum between a GEO system and an interference NGEO system under the influence of satellite disturbances. In the future, this process will move towards machine learning and computational spectrum detection. With a large number of datasets in machine learning technology, we also need to calculate probability of detection, false alarm detection, response time, miss detection, throughput and accuracy. Machine learning technology will be quite a reality in the future.

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