Chapter 6
Application of Nature-Inspired Algorithms for Sensing Error Optimisation in Dynamic Environment

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ABSTRACT

Spectrum sensing errors in cognitive radio may occur due to constant changes in the environment like changes in background noise, movements of the users, temperature variations, etc. It leads to under usage of available spectrum bands or may cause interference to the primary user transmission. So, sensing parameters like detection threshold are required to adapt dynamically to the changing environment to minimise sensing errors. Correct sensing requires processing huge data sets just like Big Data. This chapter investigates sensing in light of Big Data and presents the study of the nature inspired algorithms in sensing error minimisation by dynamic adaptation of the threshold value. Death penalty constrained handing techniques are integrated to the genetic algorithm, particle swarm optimisation, the firefly algorithm and the bat algorithm. Based on them, four algorithms are developed for minimizing sensing errors. The reported algorithms are found to be faster and more accurate when compared with previously proposed threshold adaptation algorithms based on a gradient descend.

INTRODUCTION

The present age is the age of information. Huge volumes of data are being generated at an unprecedented speed from different applications of social media, internet, search engine, space, communication etc. This has given rise to multiple major concerns in the domain of information processing and regarding the factors related to providing QoS to the users. Efficient techniques are required to be developed for

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managing, handling, processing and extracting important information from this ever-increasing dataset. This gives rise to the concept of Big Data analysis and the requirement of tools for its management. In today's world if we look around ourselves, there are ample sources of enormous amount of data and in recent advancement majority of the data sources are from different communication-oriented applications. Number of mobile users is increasing every day with a requirement of ultra-reliable and massive bandwidth. Also, with wide implementation of Internet-of-Things (IoT), huge bandwidth requirement is coming into play. Static Spectrum Allocation policy which is presently used in different countries, leads to inefficient use of spectrum, where some of the bands are over utilized and most of the bands remain under-utilized (Letaief & Zhang, 2009). Now to resolve such a scenario, people are working on cognitive radio (CR) technology where spectrum bands are dynamically sensed, shared and recycled. The implementation of CR technology requires prediction of optimized parameter set in real time environment. The prediction techniques always work on historical analysis of spectrum which involves huge processing of data. The conventional technique may not be adequate to handle the complexity and enormity of the spectrum data set. On the other hand, bio-inspired optimizations are widely and successfully used for feature extraction of Big Data set under uncertainty and noise. Therefore, in this chapter, we have tried to define the equivalence of spectrum data set and Big Data set. Once the equivalence is established, then the bio-inspired techniques may be applied for parameter prediction for different spectrum related analysis of CR technology. In this chapter, we have worked on parameter prediction for dynamic spectrum sensing.

Big Data refers to high volumes of varied types of data, structured and un-structured, streaming at exponentially increasing speed, inconsistent and of varied quality. So, Big Data is described by characteristics like volume, velocity, variety, variability and veracity (Schroeck, Shockley, Smart, Romero-Morales & Tufano, 2012). These make the conventional data processing techniques inadequate to manage and analyze to extract required information accurately. Mathematical optimization has immense applications in various fields of engineering like electronic design automation, VLSI, machine learning, signal processing, Big Data, communication, etc. Nature inspired optimization algorithms are used to efficiently analyze Big Data (Hajeer & Dasgupta, 2016).

In CR technology, the spectrum bands are allotted to the users who are not licensed, i.e., secondary users (SU) when the bands remain unused by the licensed users known as Primary Users (PU), without causing any harmful interference to the PU transmission. The SU senses the available spectrum holes (vacant spectrum band) and transmits, until PU again starts to transmit via the allotted band. Thus, spectrum sensing becomes a key issue in CR technology. A number of different spectrum sensing algorithms are described in the literatures (Letaief & Zhang, 2009; Liang, Zeng, Peh & Hoang, 2008; Zhang, Mallik & Letaief, 2008; Zhang, Jia & Zhang, 2009; Joshi, Popescu & Dobre, 2011; Li, Hei & Qiu, 2017). The energy detection method (Letaief & Zhang, 2009), multitaper method, pilot signals and matched filtering methods (Letaief & Zhang, 2009), cyclo-stationary based methods (Letaief & Zhang, 2009), and poly phase filter bank methods (Letaief & Zhang, 2009), etc., are some of the widely known methods of spectrum sensing. The techniques mentioned above are generally tested under static environment. However, practical systems are subjected to change in background noises due to temperature change, ambient interference, etc. and the spectrum usage changes as the number of active users and transmission parameter changes. Other challenges, like reliability issues, uncertainty in the performance and parameter detection in real time degrades the sensing performance and causes sensing failure problem. Also, according to IEEE 802.22 standard, any spectrum sensing technique must detect the presence of the licensed user within 2 seconds from the appearance of the user (Shellhammer, 2008). Therefore,