Literature Study on Artificial Intelligence for Cognitive Radio

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ABSTRACT

Cognitive radio, a self-organizing network provides a new way to utilize the unused spectrum with a dynamic spectrum approach. To implement such self-organizing network some artificial intelligence methods required. In this paper a comparative study of three techniques that has been used for cognitive radio implementation are summarized. The option to select artificial intelligence methods is based on three major factors; they are Stability, security and complexity. Learning is one of the important scenarios in cognitive radio networks. Some learning problems also discussed.

KEY WORDS: Cognitive Radio, Artificial Intelligence, Learning problems, Cognitive cycle.

1. INTRODUCTION

With the rapid exploitation of new wireless systems, the demand for utilizing electromagnetic spectrum is enormously increased. Conventional spectrum allocation methods will not sustain for long time for such increasing demand. New era of intelligent technology needed to withstand such demand from the spectrum users. Inefficient spectrum allocation causes more number of unused bands in spectrum available while the demand for using spectrum is increases are illustrated in Fig.1. Two types of users available for utilize the spectrum one with license and another without license so called primary users and secondary users.

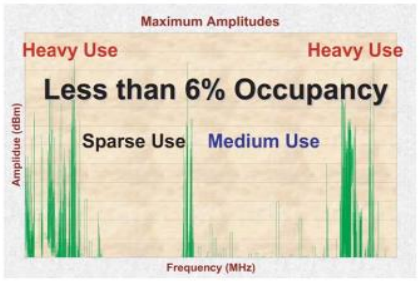

Figure.1. Spectrum Usage

Flexible spectrum allocation technology needed to solve the utilization problems of spectrum. Cognitive radio technology uses dynamic spectrum access method to control the spectrum allocation to the users at any instant of time. So spectrum monitoring and allocation is very important while using cognitive radio. Learning is the additional process is done by cognitive radio to ease the decision making in future. Cognition cycle plays a vital role in allocating spectrum dynamically which is illustrated in Fig.2. Sensing, Analysis, Reasoning and Adaptation are the four steps in cognition cycle which performs the functions like Spectrum sensing, management and allocation. Through the sensing step cognitive radio identifies the unused spectrum in the entire EM spectrum. The unused spaces are called white spaces. Then the white spaces are allocated to unlicensed users to increase the high spectrum efficiency. Artificial intelligence methods are useful to implement the cognitive radio engine. Artificial Neural Networks, Hidden Marov Model and Case based Reasoning are the three methods discussed in upcoming section.

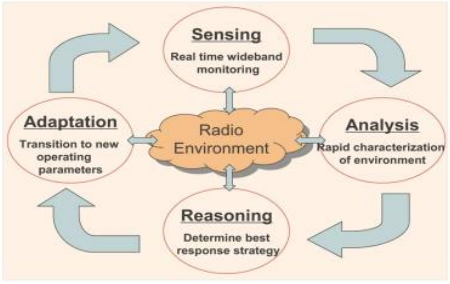

Figure.2. Cognition cycle

Artificial Intelligence Methods:

Artificial Neural Networks: The study of human brain leads to artificial neural networks for computational models. Based on the activity of neurons dynamically adjustable parameters in a network were analyzed. Decision making process of each neuron is that it collects information from its neighbors and gives the single output. Multi-layer perceptron, nonlinear perceptron and radial basis functions are the major artificial intelligence methods applicable to cognitive radio environment. Multi-layer perceptron is a linear model in which each layer outputs are in linear manner. Usually nonlinear networks offer higher flexibility than a linear one which is introduced in cognitive environment also as a nonlinear perceptron method.

Hidden Marov Model: To analyze the dynamic behavior of a complex parameter hidden markov model is used. It is a statistical model in which the output only readable and the states of each passage are hidden. Depending on the specific process the generated output may be a continuous or discrete in nature. Hidden markov model is defined with a wad equation $\Upsilon = (X, Y, \pi(1))$, where X is state of each passage with a probability of matrix M×M, Y is a observed parameter with a of matrix O×M and $\pi(1)$ initial vector a probability of matrix M×1, where M is the state and O is the unique observation state of single symbol. Three major problems identified in hidden markov model to meet the real world problems. Recognition, Decoding and learning the problems identified and which can be solved by using the above mentioned equation in addition with few algorithms. For analyzing and learning cycle in cognitive radio the hidden markov model can be used. Because hidden markov model predicts the upcoming sequences with the help of current sequence. So hidden markov model based dynamic spectrum allocation approach will provide a better results when compare to conventional spectrum allocation methods.

Case Based Reasoning: Decision based on past learning used for case based reasoning method. It is one of the artificial intelligence methods proposed. In case based reasoning, giving solution to a problem is generated by choosing the past cases which is most relevant to the current problem. Just like optimization adapting to a particular case consumes less time when compare to solving each and every problem that arises. Sometimes case based reasoning may fail if searching of a relevant problem takes long time. In such cases combination of artificial intelligence methods may imparted. Case based reasoning may have the following functions: representation, selection, evaluation and maintenance. For case based reasoning maintaining and updating a case database is important. For each decision making a case must be generated and stored as a case.

Table.1. Comparison of AI Methods

AI Method	Merits	Demerits
Artificial Neural Networks	Easily Scalable Classification of patterns is excellent Identifying new problems easily	Very slow training of neurons if the network size is big
Hidden Markov Model	Complex statistical problems are solved Prediction can be done based on experiences Easily Scalable Classification of patterns is good	Good set of training sequence needed
Case Based Reasoning	Allows learning in critical states Fast acquisition Just like human reasoning	Requires large memory Depends on previous case

2. CONCLUSION

Understanding the selection of artificial intelligence methods for cognitive radio environment gives an attainment of best cognitive engine design. Several artificial intelligence methods are summarized shortly in this paper. Opting the decision is varied depends the application. So autonomous method needs to solve the problem dynamically leads to a better cognitive radio design. Artificial intelligence shows a better commitment to solve a complex problem which arises in the radio environment. In addition to the choice of artificial intelligence methods, learning and maintaining the past experiences are important for cognitive radio environment. To accomplish this kind of requirement the way of exploring things are just started.

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