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Spectrum Sensing Analysis in Cognitive Radio Network using Spider Monkey Optimization Algorithm compare with Genetic Algorithm.

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Abstract- Cognitive Radio (CR) is the current increasing technology in wireless communication field and has increase the capability to use the frequency spectrum more accurately. The main objective of cognitive radios is to sense the neighbouring and use primary user's unoccupiedchannels and assign them to the secondary users without interference each other. This paper presents the most favourable solution and optimizes the Quality ofservices (QoS) parameters to minimum i.e. smaller as compare other solutions which are induced by different optimization techniques Genetic Algorithm (GA). The proposed algorithm called spider monkey optimization algorithm (SMO). SMO is a swarm intelligence technique which works on foraging behaviour of spider monkeys. Spider monkeys have been considered as fusion fission social structure (FHSS) based animals and they split into smaller subgroups and search food. The proposed algorithm has been used to optimize the performance of QoS parameters in terms of minimum power consumption, minimum bit error rate (BER), maximum throughput, minimum interference and maximum spectral efficiency. The simulation result shows that the fitness scores obtained by the proposed algorithm i.e. SMO are better than GA algorithm in the optimization of QoS parameters of cognitive radio system. The proposed algorithm is better than the existing algorithm.
Keywords: Cognitive Radio Network, Fusion- Fission Social Structure, Genetic Algorithm, Quality of Services, Spider Monkey-Optimization algorithm.

I. INTRODUCTION

The need of flexible and robust wireless communication has become more evident. The development in internet technologies and mobile communication systems comes as a wireless network future that helps in providing various services to customers [1].The available spectrum has been used inefficient due to use of conventional method of electromagnetic spectrum licensing. The spectrum scarcity issue has been seen due to unbalanced use of spectrum for fulfilling the different technologies need and market demand. So, proper co-ordination infrastructure and innovative licensing policies need to be introduced as a solution to above given problems. This results in increase of spectrum efficiency by enabling dynamic use of radio spectrum [2].These challenges can be solved using cognitive radio that consist smart layers for performing environment learning that helps in having better results in case of dynamic situations. The electromagnetic spectrum utilization easy way is given by it that also gives communication resources between regulations, technologies and market.

The cognitive radio origin to its development steps are given below [3]:In 1999, Joseph Mitola has given a term of cognitive radio in his doctoral thesis [4]. The Defence Advanced Research Projects Agency (DARPA) funded to Next Generation (DARPA-XG) program in 2002. One policies based spectrum management framework is created as main objective of program so that spectrum holes can be used by radios.

The spectrum bands underutilization has been confirmed by Federal Communications Commission (FCC). The Notice for Proposed Rule Making (NPRM) issues has also been considered by FCC that enables the efficient management of spectrum by Cognitive Radio technology [5]. However, for the correct utilization of frequency band andthe secondary users use the primary users bands somequality of services parameters are also fulfilled i.e. minpower consumption, minimum bit error rate, maximumthroughput, minimum interference and maximize spectralefficiency.

There are various optimization algorithms workson improvement of QOS parameters such as simulatedannealing, Genetic algorithm, ant colony optimization,particle swarm optimization etc. [6-9] in which some workswith three QoS parameters i.e. low power mode (minimumtransmit power), urgent situation mode (minimum BER) andmultimedia mode (maximum throughput) and others workswith five objective parameters which are considered in thispaper. SA works on various objectives and compares thereresult with genetic algorithm(GA) and shows that spider monkey optimization(SMO) is better than GA [6].The proposed spider monkeys optimization algorithmworks on five objective quality of services(QoS) parameters i.e. min powerconsumption, min BER, max throughput, min interferenceand max spectral efficiency. In this paper, Spider Monkey Optimizationalgorithm has been used first time to improve theparameters of Cognitive Radio system. SMO is very good in solvingcomplex optimization problems. Thus GA in paper [6] hadtested to optimization of Cognitive Radio system earlier and gives theirresults. In this paper, SMO has been applied to optimizationof Cognitive Radio system. Therefore, SMO givesbetter results than GA.

II. PROPOSED WORK

Spider Monkey Optimization algorithm is one of the latestswarm intelligence techniques. SMO is population basedsuppositious meta- heuristic and has been applied to solvecomplex optimization problems. SMO is newest algorithm asit is used in many problems till now [10-13]. SMOalgorithm is situated on foraging behaviour of spidermonkeys and this action motivates JC Bansal [10] to givesdescription about SMO algorithm. The spider monkeyssplit according to fusion-fission social structures basedanimals (FFSS). They are social in behaviour and living ingroups of up to 40-50 individuals. They divide it out intosubgroups and prepare the process to observe thefood. A female is leader of the group and have responsible for food source; frequently, if she does not get plenteousfood for their group then she splits the group into smallersubgroups that explore separately. The leader of smallergroup is also a female and the group size of smallersubgroup range from (3 to 8) members per group. Forcommunication the smaller subgroup members generally use visual and vocal cords. SMO algorithm works onbehaviour of spider monkeys and gets optimization valueswith local maxima and local maxima. Thus optimizationsolution is used in various problems to get the better values.

2.1. Main steps of spider monkey optimization (SMO)algorithm:

There are some phases of spider monkey optimizationalgorithms which are adjust by the spider monkeys arelisted below:-

a)First phase:At first stage, SMOoriginates existing range of spider monkeys presents in thegroup whose population is examined as ‘M’, where eachspider monkey ‘SNi’ i.e... (i= 1, 2………….M) is a vector ofdimension having value P. At this moment, P is the numberof variables used in the optimization problem and SNirepresents the ith spider monkey in the population. Eachspider monkey SM corresponds to the possible solution ofthe values under considered the problem. Each SNi isstarted as follows:

$$SNij = SNminj + V(0, 1) * (SNmaxj - SNminj) \quad (1)$$

b)Local Leader phase mode:After decidingfirst phase, local leader phase is the 2nd phase. In this phase, the basic step occurs when every singlespider monkey (SM) update its actual position stationed oninstruction of the local leader existence as well as localgroup member’s existence. If the fitness value of thenew location is more than that of the elderly location. Thenthe Spider Monkeys new its location with the replacednew one. The location update equation used in this positionfor ith SM is as follows:

$$SNnewij = SNij + V(0, 1) * (LLkj - SNij) + V(-1, 1) * (SNrj - SNij) \quad (2)$$

c) Global leader phase mode:After that, fulfilsthe condition of local leader phase, the global leaderphase (GLP) comes the next one phaseto starts. In GLP phase, allthe SM’s their present location using present ofGlobal leader and local member’s existence. The locationupdate equation for this phase is as follows:

$$SNnewij = SNij + V(0, 1) * (GLj - SNij) + V(-1, 1) * (SNrj - SNij) \quad (3)$$

In this phase, the active positions of spider monkeys arenew based on the action of probabilities, which are estimated using their fitness.

$$Probity = 0.9\ fitness/max\_fitness + 0.1 \quad (4)$$

d) Global leader learning (GLL) mode: In this phase the present position of the globalleader is update by applying greedy selectionin the population presents in that exacting area i.e. theregion of the Spider Monkey having ideal fitness in the population is selected as the updated positionof the global leader. After that, it is noted that the globalleader location is new as per the necessity or not andif it is not updating the position perfectly, then the GlobalLimit Count which is already selected is incremented by 1.

e) Local Leader Learning (GLL) mode:In LLL phase,the position of the local leader member is renewed byexecuting insatiable selection in that particular group i.e. theregion of the SM having perfect fitness in that group ispreferred as the renewed position of the local leader. Besidesthat the renewed position of the local leader is correlatedwith the old one and if the local leader is not renewed then the Local Limit Count is incremented by1.

f) Local leader decision (LLD) mode:In this phase,it determines that if any local leader member location is notupdate up to a there fixed threshold value called LocalLeader Limit(Llimit) and then all the constituents of that groupupdate their active positions either by random initializationor by using joined information from Global Leader andLocal Leader through eq.2.5 based on the pr.

$$SNnewij = SNij + V(0, 1) * (GLj - SNij) + U(0, 1) * (SNij - LLkj) \quad (5)$$

The above equation show that the updatedimension of this SM is turned on towards global leader andrepels from the local leader. Thus the position update ischanging and the member’s existing position changes to newposition.

g) Global leader decision (GLD) mode:this is alast phase in the SMO algorithm. In this phase, the globalleader member location is checked at the same time step bystep and if it is not update up to a fixed number ofiterations given called Global Leader Limit, then the globalleader split the population into smaller groups. Firstly, thepopulation is split into two groups and then three groupsand so on till the maximum number of groups (MaxGrp) aremaking. Each time in GLD phase, LLL process is originatedto decide on the local leader in the only just fashionedgroups. Sometimes, few conditions occurred in whichmaximum number of groups is formed and even then theposition of global leader is not new then the globalleader combines all the groups to form a single group.

ALGORITHM I: SPIDER MONKEY OPTIMIZATION ALGORITHM
Input: Select population, Local Leader limit, global leader limit, perturbation rate (Pr)
Output: calculate fitness function (shortest path).
Step 1: BEGINSelect local leader & global leader.
Step 2: Apply greedy selection process based on fitness function.
Step 3: whiledo.
Step 4: Produce new position by self-experience, local andgroup member's practice.
Step 5: Apply voracious selection process between present position and update generated position based on theirfitness function.
Step 6: Find probability Pi.
Step 7: Generateupdated position selected by probability Pi.
Step 8: Renew position of local and global leader by usinggreedy selection process.
Step 9: Renew the position of local leader by using localleader limit LLlimit.
Step 10: Renew position of global leader by using globalleader limit (GLlimit).
Step 11: end while

III. COGNITIVE RADIO PARAMETERS,OBJECTIVES AND FITNESS FUNCTIONESTIMATION

Cognitive radio is a current growing technology which has actual timecontact with the environment and this contact helps tofinds how users are converse with in the Cognitive Radio system. Cognitive Radioproduces some QoS parameters which defines how systemhas been utilized by users. Cognitive Radio system having transmissionparameters, environmental parameters with this it utilizesome set of service performance objectives.

3.1 Cognitive Radio Transmission And Environmental Parameters

Broadcast parameters:Drive as the selectionchangeable of the Cognitive Radio system. These transmission parameters orselection changeable must be well defined before earlyfitness function of various objectives. For simulation of Cognitive Radiosystem optimization the transmission parametersperformance range is used by the SMO algorithm is given below inthe table 1.

Table 1 Model Parameters

PARAMETERS	VALUES
Transmission Power (P)	0.158upto 251mW
Bandwidth(B)	2upto 32MHz
Modulation Index	2 to 256
Modulation category	QAM
Time division duplexing(TDD)	25 upto 100%
Symbol rate	125000sps upto 1Msps

b) Environmental parameters:These parameterscreate information to the Cognitive Radio system on the adjacentenvironment characteristics. This sensed data helps thecognitive instrument on making choice after find fitnessfunction. The environmental parameters used in this paperare considered as bit error rate (BER), signal-to-noise ratio(SNR), noise power and channel loss.
c) Cognitive Radio Objectives:The radio system has dissimilarattractive objectives whichimproves the wireless communication environment. In thispaper we will talk aboutdifferent Cognitive radio objectives i.e.
Minimize power consumption.
Minimize bit error rate.
Maximize throughput.
Minimize interference.
Maximize spectral efficiency.

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d) Fitness Function for Cognitive Radio System:Used for optimization of cognitive radio system, the fitnessfunctions have to be assigned to observe the searchingdirection. So to complete the needed targets, different-differentobjectives QoS parameters have been formulated. It has tobe noted that these objectives parameters are same that areformulated in previous paper [6-8]. The design goals havebeen kept same for comparison purpose.The artificial code for fitness functions are below:

3.2 Algorithm Ii: Fitness Function Of Qos Parameters

Input: Transmission parameters (P, MOD, BER, TDD, Rs) measured for fulfilling QOS parameters
Output: fitness function (y, z)
BEGIN:
Check QOS parameters needs (min power, minB.E.R, max throughput, min interference, max spectralefficiency).
Define fitness functions y(1)= fmin_power , y(2)= fmin_ber,y(3)= fmax_throughput , y(4)= fmin_interference,y(5)=fmax_spectral-efficiency.
Assign proper mass (z1, z2,z3, z4, z5) for fitnessfunction
While iteration <= iterationmax do
Renovatemass (z1,z2, z3, z4, z5) for each fitnessfunction according to current channel situation.
While (fp is optimized minimum) do
Calculate fmin_power = 1- P/Pmax
End while
While (fber is optimized minimum) do
Calculate fmin_ber = log10 (0.5)/log10 (Pbe)
End while
While (fthroughput is optimized maximum) do
Calculate fmax_throughput = 1 – log2 (M')/log2 (M'max)
End while
While (finterference is optimized minimum) do
Calculate fmin-interference = ((y (1) +y (3) +y (4))-(Pmin+Bmin+1))/ (Pmax+Bmax+Rsmax)
End while
While (fspectral efficiency is optimized maximum) do
Calculate fmax-spectraleff = 1-((y (2)*Bmin*y (5))/(y(3)*M'max*Rsmax))
End while
While (final fitness calculated) do
Calculatefinal=z(1)*fminpower+z(2)*fminber+z(3)*fmaxthroughtput+z(4)*fmininterfernce+z(5)*fma-xspectral.
End while
END

IV. RESULT STUDY

In this paper, the fitness function of performanceobjective parameters are simulated by using proposedalgorithm SMO algorithm results arecompared with the existing algorithm i.e. GA algorithmresults [6]. Thus, the simulation is carried out to evaluatedifferent performance parameters such as powerconsumption, bit error rate, throughput, interference andspectral efficiency.This model is developed and the simulation results are performed by using a software platform-MATLAB.

a) Minimize Power ConsumptionIn this objective parameter the amount of powerdevoted by the Cognitive Radio system is minimized.

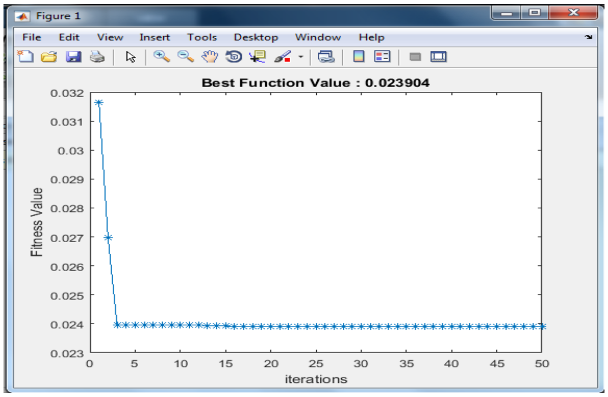

Figure 1(a): Fitness Function Convergencecategory for minimum power consumptionmethod in case of SMO.

The simulation results show by the proposed algorithm SMO is shown in figure 1 (a). Thesefigures show the changes of iteration withthe fitness value. When the number of iterations increases in case ofSMO then the fitness value is reduced to minimum. So, the lesserthe amount of fitness value obtained from the algorithm thesystem works more properly.

b) Minimum Bit Error Rate (BER)

The bit error rate (BER) is the number of bit errors perunit time. The bit error ratio is the number of bit errorsdivided by the total number of transferred bits during astudied time interval.

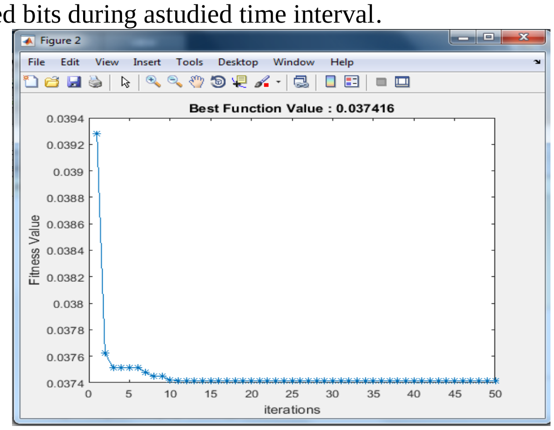

Figure 2(a): Fitness Function Convergencecategory for minimum bit error rate method in caseof SMO

c) Maximize Throughput

Throughput is the rate of successful message deliveryover a communication channel. The main objective of use ofthroughput is that the overall transmission data through thesystem is increased with less no. of time. So, thefitness function obtained by proposed algorithm i.e. SMO isless than other optimization technique. The main motive ofless amount of fitness function is that the larger number ofdata is transmitted through a system.

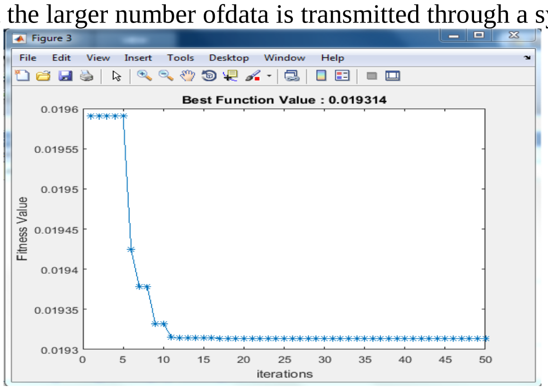

Figure 3(a): Fitness Function Convergencecategory for maximize throughput method in caseof SMO

d) Minimum Interference

The one of the purpose of Cognitive Radio system isinterference. The different optimization algorithm hadalready worked on minimizing the interference. Thus themain objective is only that to reduce the radio's interferencecontributions.

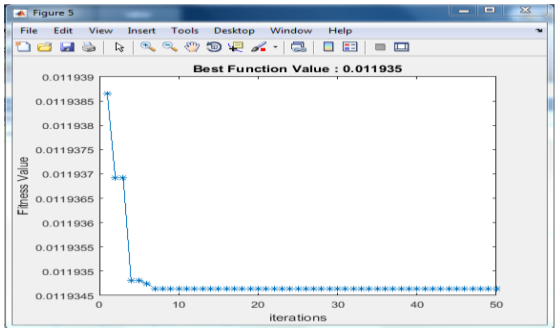

Figure 4(a): Fitness Function Convergencecharacteristics for minimum interference method in caseof SMO

e) Maximum Spectral Efficiency

Spectral efficiency refers to the information rate thatcan be transmitted over a given bandwidth in a specificcommunication system. The main objective of use ofspectral efficiency is that it maximizes the efficient use ofthe frequency spectrum.

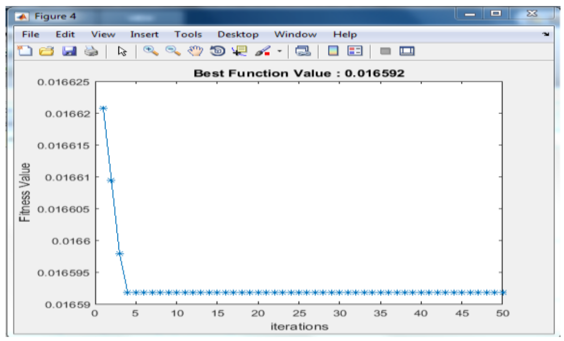

Figure 5(a): Fitness Function Convergencecategory for maximize spectral efficiency methodin case of SMO

The fitness function convergence category for differentperformance aim are performed by proposed algorithmSMO for certain QoS parameters and same parameters are shown in figure 1(a), 2 (a), 3(a), 4 (a) and 5 (a) respectively.Thus, the proposed algorithm technique SMO algorithm are compared with the existing algorithmi.e. GA from the previous paper [6].

Table 2 Comparison Table of Different Optimization Techniques

Scenarios	Spider Monkey Optimization Algorithm	Genetic Algorithm
Minimum Power consumption	0.023904	0.07151
Minimum bit error rate	0.037416	0.09097
Maximize throughput	0.019314	0.03917
Minimum interference	0.011935	0.03012
Maximum Spectral efficiency	0.016592	0.06518

V. CONCLUSION

In this paper, we have proposed SMO algorithm to minimizethe optimization problem in CognitiveRadio system. The main objective ofusing optimization algorithm in Cognitive Radio system is to optimizethe required objective and reached them to local maxima andlocal minima. The proposed system is implemented and the evaluation of the system is performed with respect to different parameters. The proposed system is implemented using several stages. This SMO approach is developed to enhance the network in terms of minimum BER, reduced power consumption, maximum throughput, minimum interference, and better effectiveness. These results of the proposed algorithm for optimizing the network using SMO gives efficient results. The best fitness values of each parameter are recorded into tabular form. It is clear from the table that the proposed system shows better performance for all the proposed

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parameters. The proposed system in terms of power consumption, Bit error rate, throughput, interference, and spectral efficiency performs effectively and efficiently as compared to the existing system Thus, the relative study ofproposed algorithm SMO to the existing algorithm GA shows that the fitness valueobtained by SMO algorithmis improved as compared to the GA.

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