Research on Soft Computing Techniques for Cognitive Radio Networks

Dr A V Prabu[1], D.Amutha[2]

[1]Associate professor, Department of Electronics and Communication Engineering, Koneru Lakshmaiah Education Foundation, Green Fileds, Vaddeswaram, A.P. – 522302
[2]Assistant Professor, Department of Mathematics, Subbalakshmi lakshmipathy college of science, Madurai
Email: prabu.deva@kluniversity.in[1]

Article Info	ABSTRACT
Article history: Received Oct 7, 2024 Revised Nov 23, 2024 Accepted Dec 15, 2024 *Keywords:* Soft Computing Techniques Cognitive Radio & Architecture Learning Methods	Numerous significant challenges are currently plaguing the field of wireless communication, drawing the attention of numerous scholars. Cognitive radio is defined as an autonomous, multifaceted radio technology that learns from its experiences to base, plan, and predict potential outcomes to meet user needs. Intelligent management, allowance, and use of scarce resources are needed by such an extremely diverse radio situation. Numerous learning and optimization techniques for soft computing, including brain networks, informal logic, evolutionary algorithms, and cluster intelligence, are drawn to problems like spectrum detection and allocation, environmental learning, or adaptability and learning ability. One of the most significant new technologies that promises to address such situations is neural radio. Cognitive radio systems, which are based on software-defined radio technology, employ clever software packages that enhance their transmitters with the remarkably remarkable capabilities of consciousness of oneself, adaptability, and learning. The intelligence engine that powers the radio uses detecting, instruction, shifting, and algorithmic optimization. to monitor and modify the radio device from the material layer to the top of the transmission stack. This paper provides a critical analysis of various approaches to soft computing applied to cognitive radio problems and also points out different avenues for the study about it.

Corresponding Author:

Dr A V Prabu,
Associate professor, Department of Electronics and Communication Engineering, Koneru Lakshmaiah Education Foundation, Green Fileds, Vaddeswaram, A.P. – 522302.
Email: prabu.deva@kluniversity.in

1. INTRODUCTION

An intellectual broadcast result from the enhancement of a product broadcast with psychological capabilities is the process that is adopted here. Those capacities are frequently given by a smart launch of a product bundle, called an intellectual motor, which upholds choices to the product based radio by constantly changing its boundaries, watching and estimating the results, and taking activities to move the radio into a state of optimal functioning. Intellectual Radios can be used to learn exercises and store them in an information base from which they can be retrieved when needed to manage decisions and actions in the future. Thinking motor determines which tasks can be completed in a particular radio environment Different learning models are worked toward range conduct, range detecting, and Spectrum getting the hang of utilizing approaches, for example, Collaborative separating [1], self-learning calculations, and AI methods [2]. Using techniques like neural networks [3], Markov models [4], and theoretical gaming [5], mathematical models for learning are also developed for unpredictable spectrum access and channel selection.

The idea behind the intellectual radio is the learning motor, which uses methods like support vector machines, neural networks, genetic algorithms, and reinforcement learning to implement mindfulness and learning. A paradigm based on neurological organization is used to work with the head of Cognitive Radio.

Signal arrangement to recognize the presence of the obscure sign is executed utilizing self-sorting out guides. Learning Models are additionally worked towards discovering boundaries to choose which the best design to work with is [6]. A learning model built with a Neural Fuzzy Interference System is used to forecast transmission rates. While some learning models, like self-composed guides, use unaided calculations, others use directed calculations. Table 1 presents a near investigation of various existing strategies delineating their benefits and comments about the method utilized. This gives a guide to the proposed philosophy.

The fundamental highlights of the CR [7] are:
• Able to detect its remote correspondence climate;
• Independently and powerfully change the correspondence boundaries to acquire the nature of administration for clients.

Along these lines, a radio must be sufficiently astute to consequently change its correspondence boundary as indicated by its natural change and the administrations requested by the comparing client and perceptions.

The way toward getting the radio climate data is pricey and complex since it includes range detecting, self-governing learning, and client collaboration, demonstrating, and thinking. Intellectual radio may reach the radio spectrum in two distinct ways, such as Opportunistic Spectrum Access (OSA) and Concurrent The Spectrum Access (CSA), depending on different psychological skills.

In the OSA model [8], a CR hub consistently searches all accessible range opening in its encompassing, when it finds the best one, plays out its correspondence activity, and changes its correspondence boundary as indicated by it. The CR must give up on maintaining zero impedance since the CR hub must constantly determine if the PU requires its range. On the other hand, the CSA model permits both PU and CR to share the approved range band, provided that the impedance is kept below the edge level because SU should not do so.
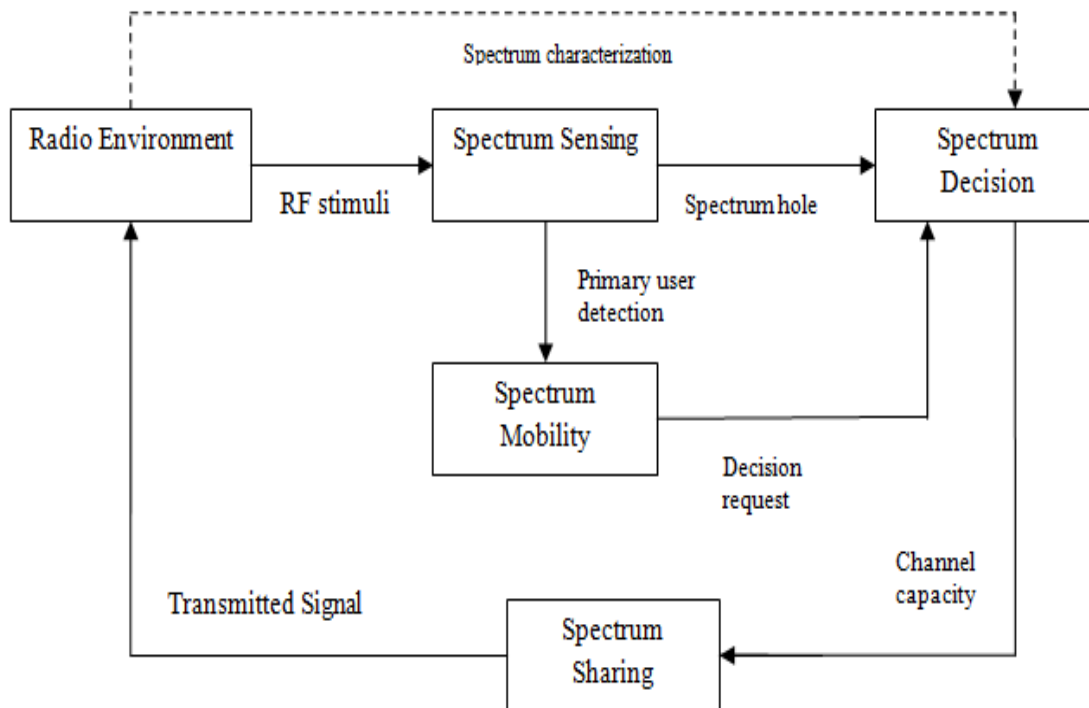
Figure 1. Cycle of Cognitive Connections

Figure 1 shows a cognitive radio cycle diagram. All things considered, it may be divided into two categories: high unwavering quality and suitable use of radio range.

Intellectual Radio innovation enhances the range use by permitting unlicensed clients to divide assets like range with the authorized client in a sharp way. The regular methodologies dependent on expository procedures for comprehension and foreseeing the conduct of psychological radio framework can end up being extremely troublesome and resolute to adapt to the multifaceted nature and unpredictability of

the issues and difficulties related to its execution. While managing intellectual radio, we need to manage the serious extent of vulnerability and to endure limit imprecision.

Customary methodologies which depend on the mathematical investigation have qualities of accuracy, whereas delicate processing approaches like fluffy rationale, neural organizations, hereditary calculation, and multitude insight have the attributes of an estimate. The upsides of utilizing delicate registeringmethods are fit to oversee the capacity to bear ambiguity and vulnerability, the minimum cost of calculation, and superior Machine Intelligent Quotient (MIQ). [9] Analyzes the detecting strategies as far as their detecting exactnesses and complexities. In any case, they haven't tended to the appropriateness of delicate processing methods in Cognitive Radio (CR). A thorough examination of numerous sensitive figure techniques and their use in CR is given in this publication. After reviewing a number of studies, it is determined that a comprehensive review is required in order to clearly illustrate the connection between careful registration and CR.

2.   COGNITIVE RADIO NETWORK ARCHITECTURE

An intellectual radio has two important subsystems: a psychology section that makes decisions based on various data sources and a flexible SDR section whose software development provides a range of possible operating modes. A different range detecting subsystem is additionally regularly remembered for building an intellectual radio to quantify the sign climate to decide the presence of different administrations or clients. Note that these subsystems don't characterize a solitary bit of hardware, however may rather consolidate segments that are spread over a whole organization. Accordingly, psychological radio is frequently alluded to as an intellectual radio framework or an intellectual organization.

The square pattern given below demonstrates the manner in which an intellectual component is additionally separated into two separate parts. The referred to as "psychological motor" works for an alternative or strengthens an advertisement objective through inputs that describe the current internal condition and operating environment of the radio. To attempt to ensure whether the arrangement presented by the "behavioral motor" is in conformance with principles of administration along with additional ways outside of the radio, the following motor is known as the "strategy motor" [10].
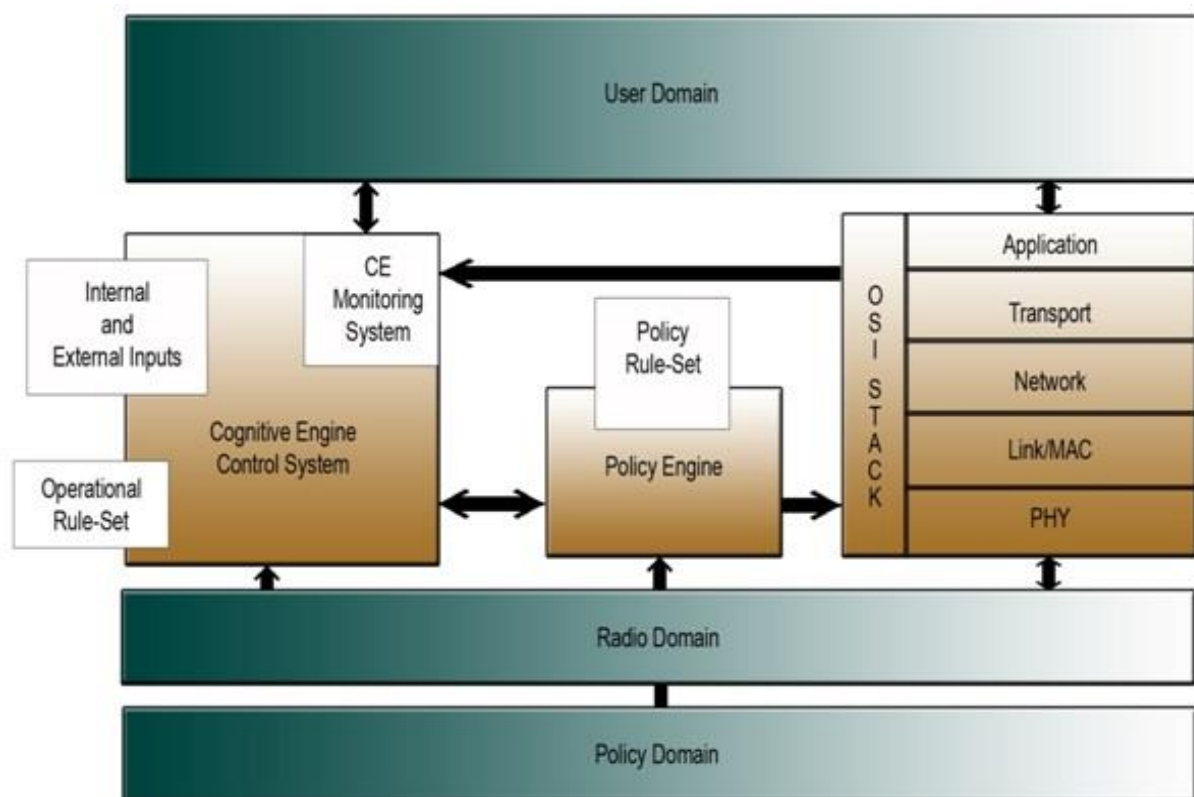

Figure 2.Cognitive Radio Network Architecture

A cognitive radio essentially holds a product characterized by radio as its equipment part. The RF front end [11], a modem, and a receiver transmitter chain are the standard components of the product-

characterized radio. From a complicated viewpoint, intellectual proportion engineering can be depicted to comprise of I) Physical Layer ii) MAC Layer ii) Network Layer and iv) Transport Layer.

i)Physical Layer-Range detecting is the essential assignment, which incorporates functionalities, for example, distinguishing range openings/openings over the wide-recurrence range, assessing the opportunity, assessing obstruction at the essential recipient (e.g., in a CDMA environment) [12].

ii)MAC Layer-MAC layer: A choice is taken on if transmission ought to be thought about that the range detecting could be broken and the way toward using the range openings (e.g., what balance and force level to utilize) and, if there should be an occurrence of transmission, on the most proficient method to impart the range to different CRs. The MAC convention functionalities additionally incorporate acquiring data on channel inhabitancy (range detecting) and settling on choices on range access, coordinating transmission boundaries (e.g., channel and time allotment) between the transmitter and collector, permitting placation among essential clients and optional clients for range assignment, permitting correspondence among auxiliary clients to perform channel detecting and channel admittance and range exchanging capacities (e.g., range offering and range pricing [13]).

iii) Network Layer-: The essential errands at the organization layer are building geography, tending to, and directing. The geography development includes range location, neighbor revelation, and geography the board (e.g., through range mobility.)[14]

iv)Transport Layer- The implementation of the MAC convention and range portability have an impact on how stream and blockage control are presented by the vehicle layer convention. The breadth of the executive's procedures normally affects the transmission control convention's throughput.

3.   SOFT COMPUTING TECHNIQUES FOR COGNITIVE RADIO

Soft computing is a methodology where we register answers for the current complex issues, where yield results are loose or fluffy, one of the main highlights of delicate figuring is it ought to be versatile with the goal that any adjustment in climate doesn't influence the current cycle. Coming up next are the qualities of delicate processing. In polynomial time, soft computing offers estimated results to NP, NP-complete, and NP-hard issues. It acknowledges doubt, partial reality approximation. The fundamental components of soft computing can be found in figure 3.
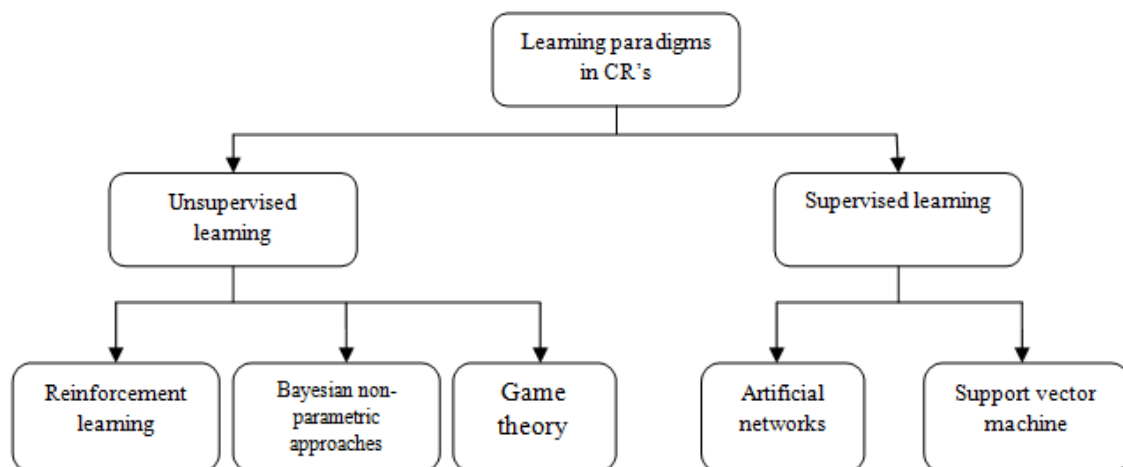

Figure 3. Parts of Soft Computing Techniques

No mathematical modeling is required to solve any given issues [15].

When we resolve an issue with one input from time to time, it provides various solutions, using certain physicallystimulatedtechniques such as biology, development, swarming particles, the human nervous system, etc.

Artificial Neural Network, Fuzzy Logic, Genetic Algorithm are the three types of soft computing techniques.

3.1 Artificial Neural Network in Soft Computing

It is a connectionist displaying an equal appropriated system. Totally two kinds ANN (Artificial Neural Network) and BNN (Biological Neural Network). A neural organization that measures a solitary component is recognized as anelement. The segments of the item are input, weight, preparing component, yield. It is like our human neural framework. The principal benefit is that they take care of the issues in equal,

fake neural organizations utilize electrical signs to impart. In any case, the principle disservice is that they are not shortcoming open-minded that is on the off chance that anybody of fake neurons gets harmed it won't work any longer.

An instance of a handwritten quality, where many people write a character in Hindi, they may write a similar character but in a diverse shape. As seen below, we can understand the character in any manner they write, since one already knows how the character looks. It's possible to equate this definition to our neural network system.
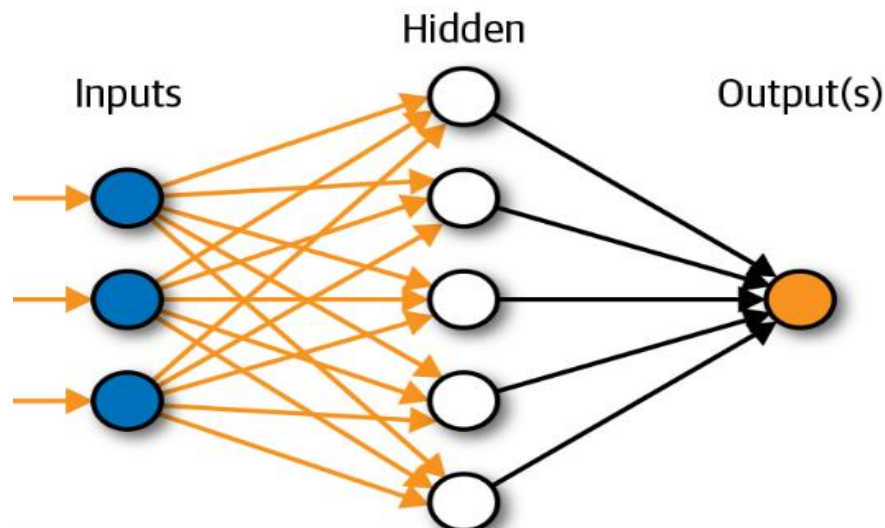

Figure 4. ANN

3.2 Fuzzy Logic in Soft Computing

The fuzzy logic algorithm is utilized to resolverepresentations that, like imprecise and ambiguous, are based on logical reasoning. The fuzzy logic gives a closed interval with a stipulated truth value [0,1]. Where the value 0=false, the value 1=true.

An instance of a robot that needs to travel within a short time from one position to another where there are several obstacles, the robot can measure its motion to attain the target point. These types of issues have problems of ambiguity that can be solved using fuzzy logic.
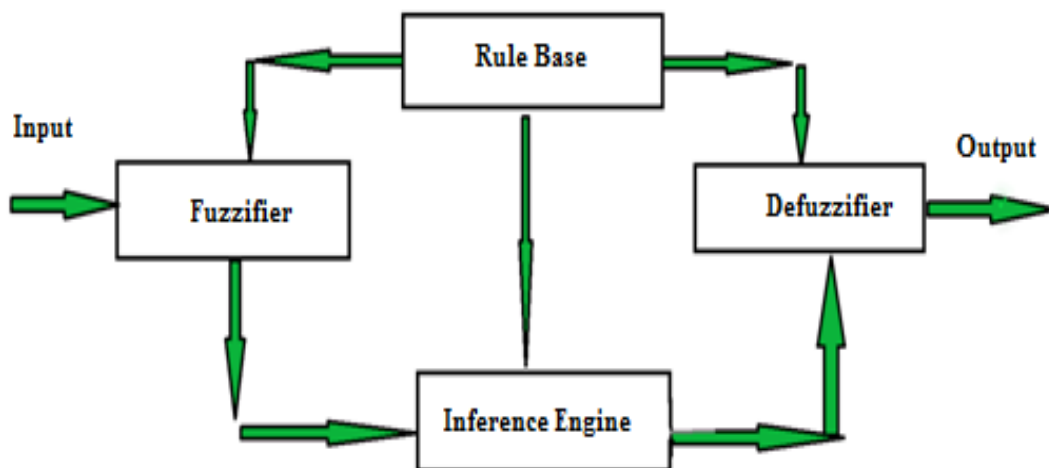

Figure 5.The Architecture of Fuzzy Logic

3.3Genetic Algorithm

The Genetic Algorithm was initially presented at 965 by Prof. John Holland. It is utilized to tackle issues dependent on standards of common determination that go beneath developmental calculation. They are normally utilized for streamlining issues like augmentation and reduction of target capacities, which are of

two sorts of a subterranean insect state and multitude molecule. It follows natural cycles like hereditary qualities and advancement.

An easy way to understand this algorithm is to know that different bans are available with different schemes and policies by taking the given instance of a person who wishes to spenda little cash in the bank. The individual interest is the amount to be invested in the bank so that maximum benefit can be achieved. For the individual, there are certain requirements, which are how they can invest and how they can benefit from investing in the bank.
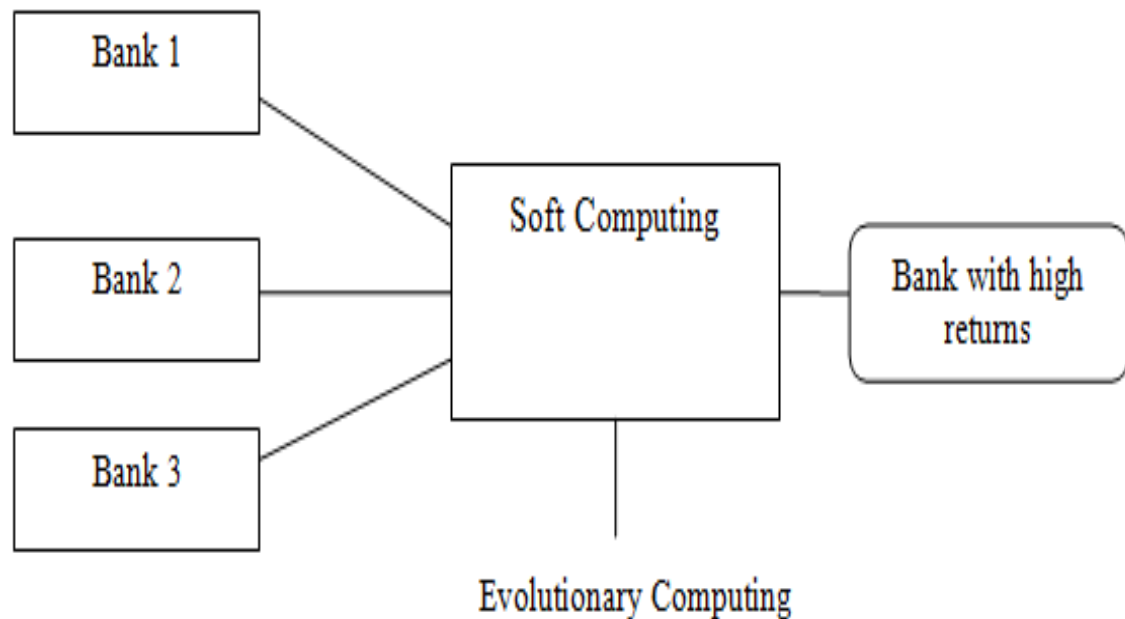

Figure 6. Genetic Algorithm

4. APPLICATIONS OF SOFT COMPUTING

To embrace a powerful remote climate in[16] proposed a psychological motor plan dependent on the Genetic Algorithm and Radial Basis Function (RDF) Neural Network (RBF-NN), they have exhibited the viability of the model through recreation. In 2013, [17] used the concepts of soft logic and artificial neural networks to address problems such as proficient range usage in intellectual radio. They tended to this issue basing on portability, QoS, and need. [18] have done a detailed overview of different learning strategies accessible for the setting to CR. [19] gave an investigation on shut structure articulation between distinguish likelihood and bogus caution likelihood for the concentrated co-usable organization in CR dependent on the Fuzzy choice plan.

All wellbeing data is transmitted based on FLS in this framework, which uses the psychological organization standard to wave in order to increase the range allotted to the control stream by the 802.11p amendment.

In [20] zeroed in on the range handoff in CR and utilized fluffy rationale to anticipate a saved channel table. [21] proposed a fluffy rationale based Artificial Mapping Tree (AMT) for Dynamic Resource Management issue in intellectual radio. A Fuzzy Logic-based co-usable range detecting and contrasted this technique and ordinary agreeable range detecting strategy and discovered proposed plot is outperforming. By utilizing the Fuzzy Inference System determined a summed up choice surface for shrewd range booking. A versatile dynamic framework for the determination of strategies to get information on range accessibility and found that their choice causing framework to can improve the achievement rate essentially. In 2013, [22] proposed a calculation dependent on the fluffy rationale to manage range handoff and demonstrated the promising advantage of the calculation. The channel positioning calculation dependent on fluffy rationale hypothesis to decide appropriately the genuine ease of use of vacant channels and discovered their methodology is more productive than that of customary fresh worth based methodology. A two-phase Scheme-Fuzzy Hypothesis Evaluation Dependent Collection Co-difference Matrix (FHTSCM) for important client signal location and reproduction is proposed in [23]. The likelihood of discovery for different SNR levels is introduced, and the 2k method of the DVB-T transmission is completed. In [23] proposed a fluffy

rationale based channel task to versatile optional clients by thinking about thickness, clamor, portability, channel choice likelihood as a boundary.

5.   CONCLUSION

This work critically examines the application of methodologies for soft computing in cognitive radio. The fundamental issues of cognitive radio, as well as different settings and their effects, were covered at the outset of the debate. Numerous issues have been identified that impact the cognitive radio scheme. The use of soft computing methods in cognitive radio functions has been illustrated in the second part of the survey. This provides the opportunity to maintain an effective balance between discovery and development for the swarm-based algorithm. It has also been learned that when developing a swarm-based algorithm to resolve cognitive action, the number of goals that will make it more versatile should not be limited by radio problems.

REFERENCES

[1]   Husheng Li New Frontiers in Dynamic Spectrum, 2010 IEEE Symposium on 6-9 April 2010, Learning the Spectrum via Collaborative Filtering in Cognitive Radio Networks.

[2]   Jiangyin, SiXing Yin, Weijun Hong, Shuang Li, Senior Member IEEE,2011 Military Communicationsthe conference, Spectrum Behaviour in Cognitive Radio Network based on Artificial Neural Networks.

[3]   Nicola Baldo, Bheemarjuna Reddy Tamma, B. S. Manoj, Ramesh Rao, and Michele Zorzi IEEE Communications Society,2009, A Neural Network-based Cognitive Controller for Dynamic Channel Selection.

[4]   Unnikrishnan, J., Veeravalli, V.V. Signals, Systems and Computers, 2008 42nd Asilomar Conference on, 26-29 Oct.2008, Dynamic spectrum access with learning for cognitive radio.

[5]   Van Der Schaar, M. Proceedings of the IEEE, April 2010, Volume: 97, Issue: 4 Spectrum Access Games and Strategic Learning in Cognitive Radio Networks for Delay-Critical Applications.

[6]   K. Tsagkaris, A. Katidiotis, P. Demestichas, International Journal on Computer Communication, (2008) 3394–3404, Neural network-based learning schemes for cognitive radio systems.

[7]   Akyildiz, I. F., Lee, W., Varun, M. C., & Mohanty, S. (2006). Next-generation/ dynamic spectrum access/ cognitive radio wireless networks: A survey. Science Direct, computer. Networks, 50(13), 2127–2159.

[8]   Xu, Y., Wang, J., Wu, Q., Anpalagan, A., & Yao, Y. (2012). Opportunistic Spectrum Access in Cognitive Radio Networks: Global Optimization Using Local Interaction Games. IEEE Journal of Selected Topics in Signal Processing, 6(2), 180–194. doi:10.1109/JSTSP.2011.2176916

[9]   Preet, A., & Kaur, A. (2014). A State Review paper on Cognitive Radio Networking and Communications.International Journal of Computer Science and Information Technologies, 5(4), 5508–5511.

[10]   https://www.wirelessinnovation.org/Cognitive_Radio_Architecture#:~:text=Cognitive%20Radio%20Concept%20 Architecture,range%20of%20possible%20operating%20modes.

[11]   COGNITIVE RADIO APPLICATIONS IN SOFTWARE DEFINED RADIO, John Polson.

[12]   Evolution and future trends of research in cognitive radio: a contemporary survey Ekram Hossain1*, Dusit Niyato2, and Dong In Kim3 1 University of Manitoba, Winnipeg, Canada 2 Nanyang Technological University, Nanyang, Singapore 3 Sungkyunkwan University SKKU, Seoul, Korea.

[13]   Spectrum Auction Framework for Access Allocation in Cognitive Radio Networks Gaurav S. Kasbekar University of Pennsylvania, kgaurav@seas.upenn.edu SaswatiSarkar University of Pennsylvania

[14]   Solving Hidden Terminal Problem in Cognitive Networks Using Cloud Technologies Yenumula B. Reddy Grambling State University, USA

[15]   What is Soft Computing: Techniques and Differences- https://www.elprocus.com/soft-computing/

[16]   Yang Y., Jiang H., Liu C. &Lan Z. (2012). Research on Cognitive Radio engine based on Genetic Algorithm and Radial Basis Function Neural Network. Proceedings of the IEEE Spring Congress on Engineering & Technology (S-CET) (pp. 1-5).

[17]   Potdar, M., & Patil, K. D. (2013). Efficient Spectrum Handoff in Cognitive Radio Network Based on mobility, QoS, and priority using Fuzzy Logic and Neural Network. Proceedings of theSixth International Conference on Contemporary Computing (IC3) IEEE (pp. 53-58). doi:10.1109/IC3.2013.6612161

[18]   Bkassiny, M., Li, Y., & Jayaweera, S. K. (2013). A Survey on Machine-Learning Techniques in Cognitive Radios. IEEE Communications Surveys and Tutorials, 15(3), 1136–1159. doi:10.1109/SURV.2012.100412.00017

[19]   Zhang, H., & Wang, X. (2011). A Fuzzy Decision Scheme for co-operative Spectrum Sensing in CognitiveRadio. Proceedings of the the73rd Vehicular Technology Conference.

[20]   Liu, F., Xu, Y., Guo, X., Zhang, W., Zhang, D., & Li, C. (2013). A spectrum handoff strategy Based on channel reservation Cognitive Radio Network. Proceedings of the3rd International Conference on Intelligent System Design and Engineering application (pp. 179-182). doi:10.1109/ISDEA.2012.48

[21]   Liu, F., Xu, Y., Guo, X., Zhang, W., Zhang, D., & Li, C. (2013). A spectrum handoff strategy Based on channel reservation Cognitive Radio Network. Proceedings of the3rd International Conference on Intelligent System Design and Engineering application (pp. 179-182). doi:10.1109/ISDEA.2012.48

[22]   Anuar, M. R. K., Mohammad, H., & Ramli, N. (2013). Efficient Handover Algorithm using Fuzzy Logic Underlay Power Sharing for Cognitive Radio Wireless Network. Proceedings of the IEEE Symposium on Wireless Technology and Application (pp. 53-56).

[23] Bayrakdar, M., & Calhan, A. (2015). A Fuzzy Logic Based Channel selection for Mobile Secondary User in Cognitive Radio Networks. Proceedings of the IEEE 23rd Signal Processing & Communication applicationsConference (pp. 331-334).