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A. Pasumpon Pandian
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Tomonobu Senjyu *Editors*

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M. Narayanan · Tomonobu Senjyu
Editors

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It is our genuine gratefulness and warmest regard that we, ICICCS 2021, dedicate this book to a wide spectrum of young researchers in the "computing, informatics and control" fields. We also dedicate this book and give special thanks to all the reviewers, authors and committee members for their presence throughout the entire conference program.

Preface

It is with deep satisfaction that I write this Preface to the Proceedings of the 3rd ICICCS 2021 held in CARE College of Engineering, Trichy, India, on July 02–03, 2021.

This conference was bringing together researchers, academics and professionals from all over the world, experts in intelligent control technologies, intelligent computing technologies and intelligent information systems.

This conference particularly encouraged the interaction of research students and developing academics with the more established academic community in an informal setting to present and to discuss new and current work. The papers contributed the most recent scientific knowledge known in the field of intelligent computing models and systems, intelligent information systems, fuzzy sets, intelligent computing technologies, control applications on automotive, energy, autonomous systems, big data and machine learning. Their contributions helped to make the conference as outstanding as it has been. The local organizing committee members and their helpers put much effort into ensuring the success of the day-to-day operation of the meeting.

We hope that this program will further stimulate research in intelligent systems and computing, and provide practitioners with better techniques, algorithms and tools for deployment. We feel honored and privileged to serve the best recent developments in the field of intelligent control and automation, knowledge-based systems, computational and communication constraints, network intelligence and network control and fuzzy logic control through this exciting program.

We thank all the authors and participants for their contributions.

Trichy, India
Nova Scotia, Canada
Secunderabad, India
Okinawa, Japan

A. Pasumpon Pandian
Conference Chair
ICICCS 2021
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M. Narayanan
Tomonobu Senjyu
Guest Editors—ICICCS 2021

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ICICCS 2021 would like to acknowledge the excellent work of our conference organizing committee and keynote speakers for their presentation on July 02–03, 2021. The organizers also wish to acknowledge publicly the valuable services provided by the reviewers.

On behalf of the editors, organizers, authors and readers of this conference, we wish to thank the keynote speaker Dr. Manu Malek, Alcatel-Lucent Bell Labs and Stevens Institute of Technology (ret.), New Jersey, USA, and the reviewers for their time, hard work and dedication to this conference. The organizers wish to acknowledge Prof. A. Pasumpon Pandian, Dr. Ram Palanisamy, Dr. M. Narayanan and Prof. Tomonobu Senjyu for the discussion and suggestion, and finalize the paper of this conference. The organizers also wish to acknowledge speakers and participants who attend this conference. Many thanks are given for all persons who help and support this conference. ICICCS 2021 would like to acknowledge the contribution made to the organization by its many volunteers. Members contribute their time, energy and knowledge at a local, regional and international level.

We also thank all the chair persons and conference committee members for their support.

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Review of Metaheuristic Optimization Technique for Tumor Detection from Brain MR Images

Sharma Himanshu and M. S. Choudhry

Abstract The brain tumor is a very common disease among humans. It can be deadly if not diagnosed in its early stage. Magnetic resonance imaging (MRI) is a commonly used technique to diagnose cancer. Despite providing highly valuable information regarding tumor, it is also prone to give human-prone error. Recently, various computer-aided diagnosis (CAD) techniques are being developed to improve performance of MRI. This paper presents a general metaheuristic algorithm followed by a review on different metaheuristic optimization technique-based CAD systems which provides better detection and classification results for MR images. The word meta means "trial and run," and heuristic means an "approach" to find a solution. So together, metaheuristic is a method that uses a trial-and-run approach to find an effective solution. In the end, metaheuristic optimization techniques are compared with other methods to know their productivity and better usability in the near future.

Keywords Magnetic resonance (MR) imaging · Metaheuristic algorithms · Brain tumor

1 Introduction

According to the database approved by the American Society of Clinical Oncology (ASCO), brain cancer ranks 10th among the causes of death. It has a high mortality rate of 2.5% per 100,000 persons examined with a survival rate of approximately 5 years. The brain tumor is fully curable if it is detected in its early stage. Therefore, it is important to identify the tumor in its initial stage. Currently, there are several techniques which are used by neurologists to detect brain tumor, namely computer tomography scan (CTS), magnetic resonance imaging (MRI), angiography, etc. However, due to the reasons like complexity and inaccuracy, these techniques are prone to human error which may lead to inaccurate results. To prevent this, a computer-aided diagnosis (CAD) has been developed.

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A conventional CAD system has five stages, namely image acquisition, preprocessing, segmentation, feature extraction/selection and classification. (1) Image acquisition—Image is acquired in the system from source. (2) Preprocessing—Here the image which is acquired is further processed so that some unwanted noise is removed through various filters like median filter, Gaussian filters, etc. (3) Segmentation—This step helps to segment the desired region from the images; mainly the affected region is taken out, and the unwanted part of image is discarded; some methods like water shed method, clustering method, threshold method, etc. are used. (4) Feature extraction and selection—Here some of features of the image are extracted; mainly texture-based features are taken into consideration like entropy, energy, correlation, etc., and in case of feature selection out of whole lot features, few are selected based on certain criteria/conditions; these selected features are then used further in classification step and help to classify the type of tumor; methods like genetic algorithm and others optimization algorithms can be used. (5) Classification—Using various classification methods like SVM, neural network, etc., the extracted image is classified and defined as malignant or benign tumor. CAD assists in better detection and classification of brain tumors. This paper mainly focuses on metaheuristic optimization-based CAD system.

Optimization is a process of finding the best fit solution for the required problems which are from different fields. There are different types of optimization techniques which are divided based on focus and characteristic; the researchers have called all modern nature-inspired division algorithm as metaheuristic. The word meta means "trial and run," and heuristic means an approach to finding a solution, so together metaheuristic is a method that uses a trial-and-run approach to find an effective solution. It is very effective and can also be used for nonlinear function optimization. There are mainly two important components under any metaheuristic algorithm, namely intensification and diversification. Intensification mainly focuses on local search-based, while diversification is a global search-based category. In the recent scenario, these techniques are gaining popularity in the field of medical imaging (Fig. 1).

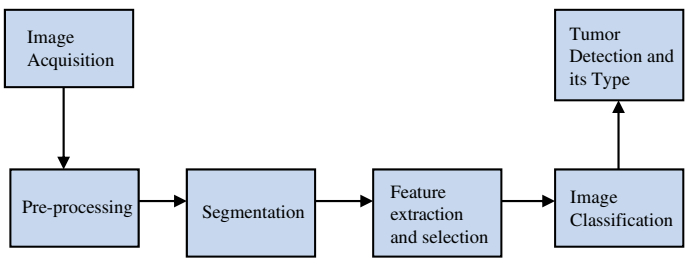

Fig. 1 Brain tumor detection flow graph

This paper reviews techniques like Artificial Bee Colony (ABC), Ant Colony Optimization (ACO), Cuckoo Search (CS), Bat Algorithm (BA), Differential Evolution (DE), Firefly Algorithm (FA), Genetic Algorithm (GA), Gray Wolf Optimization (GWO), Harmony Search (HS), Krill Herd Optimization (KH), Level Set (LS), Monkey Search (MS), Particle Swarm Optimization (PSO), Stimulated Annealing (SA) and Water Cycle Algorithm (WCA).

2 Literature Survey

Emrah et al. [1] discussed the use of the Artificial Bee Colony (ABC) algorithm which is famous for diverse real-world problems. The algorithm is explained using the bee foraging nectar method which tries to find the best solution. They explain its working and also compare it with other methods like Genetic Algorithm (GA), fuzzy C-means and K-means to show its better accuracy result.

Lee et al. [2] give an insight into Ant Colony Optimization (ACO) which is inspired by the behavior of swarms' intelligence. Its performance based on self-organization which mainly depends on the control over swarm members. Here the result shows that even a thin layer of tumor is segmented which leads to better detection.

Priyadharshini et al. [3] cover the Bat Algorithm which is based on the bat ability of echolocation; each bat has a particular frequency and sound which helps them to find their target (fitness function), so in this process of finding target, we can change amplitude and pulse rate emission to get different targets or fitness function. It further compares the overall accuracy which is improved with the use of this algorithm.

Ben George et al. [4] cover another widely used algorithm, i.e., Cuckoo Search algorithm which follows the brood parasitism and levy flight method to get an optimally fit solution. They explain its working and also compare with other methods to show its accuracy.

Ramadas et al. [5] discuss Differential Evolution technique and discuss its unique behavior of mutation and crossover which makes it different from other evolutionary algorithm. Furthermore, the transferred DE is used to find an optimal thresholding so that the final accuracy of detecting brain tumor increases.

Deshpande et al. [6] discuss the Firefly Algorithm which tells about the nature of firefly (solution) been attracted toward brightest fireflies (fitness function) to communicate with their neighbors which is used in detecting brain tumor.

Halder et al. [7] propose the very common optimization problem, namely Genetic Algorithm (GA) which is basically founded in 1975; it comes under evolutionary algorithm; it works similarly like a natural evolution and modifies a population of individual at each stage of evolution. They also discuss that how it can be used to reduce the error from the final classification output.

Attar et al. in their paper [8] discuss Gray Wolf Optimization algorithm which works analogy like wolf hunting in a pack, with fitness function can be quality of positioning of the wolf, and there is relocalization of the wolf on seeing the enemy

which can be treated as reinitialization. They also discuss that how it can be used to reduce the error and increased computation time which results in better detection.

Moh et al. in their paper [9] cover the modified Harmony Search algorithm and state how the nature of skilled musicians can be effectively used to improved segmented output than commonly used methods like fuzzy C-means, etc.

Preethi et al. [10] discuss the Krill Herd approach of finding the best solution, which is usually based upon herding process to find the food (best solution). This method is also compared with other methods, and in the end it is shown how final accuracy has been increased.

Khalil et al. [11] discuss the Level Set Algorithm and how it is used to detect brain tumor in brain MR images using interface surface to detect the brain contour, it also compares its performance with other methods like fuzzy c-means, SVM, random forest, etc. and states how it increases the overall accuracy.

Alagarsamy et al. [12] discuss the behavior of monkey characteristics of finding food which includes mainly climb, watch jump, somersault steps; mainly they act as a local optimizer, fitness exploration and exploring new regions, respectively. It compares the performance with other algorithms also and tells us about how effective this technique in detecting brain tumor.

Dixit et al. in their paper [13] discuss another technique which is Particle Swarm Optimization. It is a very effective technique and now widely used in detecting brain tumor. The algorithm states the nature of particle swarm and explains how they are finding the particle best (pbest), global best (gbest), local best (lb) solutions. This method is also compared with other methods, and in the end, it is shown how final accuracy has been increased.

Ben Ayed et al. in their paper [14] discuss the Simulated Annealing method, where the nature of slow cooling is appreciated in making crystal and uses this method to improve the accuracy, which helps in the classification of brain tumor more accurately. Ara et al. in their paper [15] discuss the Water Cycle Optimization techniques which usually have three steps like precipitation (random initialization), percolation (finding the best solution) and evaporation (reinitialization of solution). In the end, increased accuracies of the brain tumor detection are also discussed.

3 Generic Metaheuristic Algorithm

This section provides an insight on generic algorithm which is followed by almost every metaheuristic technique.

Algorithm: General Metaheuristic Structure
Require: PP, CP, SP, UP, EP, N ($\geq$ 1), α ($\leq$ N), β, γ ($\leq$ N)
1: Initialize counter with value($z = 0$)
2: Define finite number of solution Xp
3: Assess every member in solution Xp
4: identify finest solution in Xp as Sp
5: reiterate the above steps
6: Pick α solutions (Pp) from Xp using Preference plan (PP)
7: Create β solutions (Ct) from Pp using Creation plan (CP)
8: Pick γ solutions (Rp) from Xp using Substitution plan (SP)
9: Upgrade Xp by Substituting Rp taking γ solutions from
Pp, Cp, and Rp using upgrade plan (UP)
10: Assess every member of Xp
11: Identify finest solution in Xp and update Sp
12: $p \leftarrow p + 1$
13: Continue till end plan(EP) is satisfy
14: Identify the best fit solution as S*p

Require statement states the requirement of plans, namely Preference Plan (PP), Creation Plan (CC), Upgrade Plan (UP), Substitution Plan (SP), End Plan (EP) along with the parameters like N, α, β, γ, meanwhile the individual plans may involve the different parameters depending upon their algorithm. The different steps of the general metaheuristic algorithm can be explained as follows:

Step 1: Setting the counter value to zero to find the best solution need by a loop to operate with the help of a counter.

Step2: Finite no. of solutions Xp are generated randomly between the limits set by a user or algorithm. These solutions are generated according to the problem-specific or app lication-specific; in some cases, if already defined values are present then they could be directly taken from the source.

Step 3: Assessing each member of Xp by using a certain objective and limit function, each member is needed to follow the constraint to remain in the solution.

Step 4: After identifying the constraint member, the next step is to identify the finest solution from the set and marked as Sp; each member is first used in the certain objective function and then a pairwise comparison is done; if both feasible, then choose the one with best fit value or the one which is satisfying the user set criteria.

Step 5: This step is to repeat the following steps until it finds out the termination condition or the end plan met; this is done to find out the best fit solution.

Step6: Pick α solution Pp using preference plan which is very important in meta-heuristic algorithm to find the best solution. Each algorithm ha s a unique preference plan which is followed to find a solution.

Step 7: A Creation plan is used, and population is created based upon search operation; these plans vary according to the particular metaheuristic technique.

Step 8: Pick γ worst solution Rp using Substituting Plan to remove the worst solutions from the solution set. Substituting Plan is also application-specific; the term worst can be good to other algorithms.

Step 9: Upgrade Set, hereafter removing worst solutions from any of the set, namely Ct, Pp, Rp, Xp is upgraded.

Step 10: Here again evaluation of each member of Xp is done.

Step 11: The finest solution in Xp set is identified and marked as Sp.

Step 12: The counter value has incremented.

Step 13: Continue until the End Plan gets reached. This End Plan is also application-specific as discussed above.

Step 14: Finally the best fit solution is chosen.

This is the general algorithm followed by almost every metaheuristic algorithm, to find the best solution. From these techniques, Preference Plan (PP), Creation Plan (CC), Upgrade Plan (UP), Substitution Plan (SP), End Plan (EP) can be analyzed along with the parameters like N, α, β, γ, etc. depending upon the techniques used.

4 Techniques and Working Principles

This section gives an insight of various techniques based on Generic Metaheuristic algorithm along with their working principles.

4.1 Ant Colony Optimization (ACO)

ACO is under classification category of Swarm Intelligence. It is invented by Italian scholar M. Dorgio. It is based upon the observation of real ant behavior and how they are choosing an optimal path to find their food sources, they move from one place to another and meanwhile depositing a chemical substance named pheromone in their path, pheromone has a property of depletion with time so after been deposited in a line, it needs to be put again and again in their path so that the group remains in a line does not gets lost in between and ant can able to remain in the dedicated path. It could happen several times that these ants would not able to find pheromone; in such cases, they follow the random direction in search of the food and deposit these substances in the path [16]. Such nature of finding food by following a short/long path helps to find the optimal solution; this nature of ant is used by researchers to find various optimization solutions.

4.2 Artificial Bee Colony Optimization (ABC)

ABC is under classification category of swarm intelligence. It is first suggested by karaboga; it depends on bee's forging their food in a different direction here food source need to be found with having, highest nectar content is the objective function of problem so the nature of bee is to find the best solution that is considered as

Artificial Bee Colony Optimization [17]. The bees are divided into following three categories:-

Employed bees: It has a work to locate food and store in memory along with finding new sources in its neighborhood.

Onlooker bees: It selects the best food source from employed bees with the highest nectar content and keeps in its memory.

Scout bees: When employed bees unable to update their food location, again they follow the path randomly and searches for good food content. For every food source, the number of scout bees is generally one.

4.3 Bat Algorithm (BA)

BA is under classification category of swarm intelligence. It uses the process of echolocation to detect the prey; here a bat uses sound waves which have different frequencies and velocities to locate its prey. The sound wave can be modified amplitude-wise or pulse emission rate until the optimization solution met [18].

4.4 Cuckoo Search (CS)

CS is under classification category of swarm intelligence. The algorithm states that a cuckoo bird uses levy flight method to lay an egg into a randomly selected host nest. It does not have its own nest so it depends upon the host bird's nests to have its eggs. If in the worst case the host detects the egg, then it can either throw away or abandon its nest, finding the best nest, and the nest will not get destroyed which is the best optimized solution from this algorithm [19].

4.5 Differential Evolution (DE)

DE is under classification category of evolutionary algorithm. It is proposed by "Storm and Price," a stochastic population-based technique, in which the formation of the chromosome followed by recombination after mutation. Here, the target vector is set which is converted into a donor vector using mutation; this donor vector is further recombined to form a trial vector [20]. The trial vector helps to find out better solutions to the particular problem. In process of choosing a better solution using trial and target vector, the greedy selection method is used. So, the optimized solution is generated in the end.

4.6 Firefly Algorithm (FA)

FA is under classification category of swarm intelligence. It is a soft computing technique; this algorithm captures the behavior of firefly, produces short and rhythmic flashes. This process of producing flashlights is called bioluminescence, which helps them to find their food/partner. The intensity of light is inversely proportional to distance square, which finds the best path to achieve its optimization; it can be simply achieved by the efficiency of flashing light [21].

4.7 Genetic Algorithm Optimization (GA)

GA is under classification category of evolutionary algorithm. Introduced in 1975, one of the widely used metaheuristic techniques, it basically mutates the biological process of a living organism; its algorithm can be discussed as follows; firstly, random population is generated from its random population, then tournament selection is done to choose mating pool (parents), third, the crossover process is done between the parents to produce offspring these offspring mutates again to produce offspring; this produced offspring is the best fit solution [22].

4.8 Gray Wolf Optimization (GW)

GW is under classification category of swarm intelligence. They are the basic style of wolf hunting; the wolf has peculiar nature of hunting in a pack; this pack also has some divisions like the first is an Alpha group—it consists of the wolf who is leading their packs, they are decision-makers. The second is the Beta group—they have the responsibility to maintain discipline and see that everybody is following the Alpha group. The third is the Delta group—they are smaller in rank and mainly consists of hunters, sentinels, scout, etc. Fourth is the Omega group—they are scapegoats and usually get to eat in the end. Wolf hunt follows procedures like encircling its prey, hunting attacking the prey till it stops, then again go to exploration, i.e., search for prey, this is how it is used to find its prey or we can say optimized solution [23].

4.9 Harmonic Search (HS)

HS is under classification category of evolutionary algorithm. The algorithm states the nature of skilled musicians and sees their adaptive nature in improvising. There are mainly four factors that define HS: (i) adjusting memory size, (ii) setting memory considering rate, (iii) setting pitch rate and (iv) defining certain stopping criteria. Here

pitch can be taken just like fitness function which helps to determine the optimization quality [24].

4.10 Krill Herd (KH)

KH is under classification category of swarm intelligence. It is one of the algorithms which use the herding behavior of Krill, mainly the factors which define the nature of Krill optimization are the movement of Krill other than this factor like its weight, no of runs, speed, etc. The motive is to maximize these factors to get the best solution out of this [25].

4.11 Level Set (LS)

LS is under classification category of non-living intelligence. This method tells methods to monitor different shapes especially the shapes with different structures the algorithm depends upon two factors, firstly to find out the position where the interface should be inserted so to get proper brain tumor contour and secondly the speed of the interface is also mattered to find the accurate region [26].

4.12 Monkey Search Optimization (MS)

MS is under classification category of swarm intelligence.

The monkey search algorithm shows the traits of monkey and how it is used to find their food; the process shows that how they "climb" a tree can be considered as a local optimizer; watch and jump is an exchange of fitness landscape information and final trait of somersault enables exploration of new regions which in short helps to find out the best optimization solution [27].

4.13 Particle Swarm Optimization (PSO)

PSO is under classification category of swarm intelligence. It is based upon the population of flying insects called a swarm, every swarm as a particular position vector and velocity vector associated with it. There is predefined personal best (pbest) and global best (gbest); pbest is local and considered the best solution, so for every particle in a swarm topology, these things are informed previously. So the particle follows a certain updating rule w.r.t position and velocity and in the end, tries to converge toward the gbest solution [28].

4.14 Simulated Annealing (SA)

SA is under classification category of non-living intelligence. It states the process of formation of a crystal, so basically, the formation of a crystal involves the process of cooling the metal, slowly to make a proper crystal from it. The convergence function follows Boltzmann Probability Distribution, the algorithm begins with an initial point at high temperature; secondly, the difference in energy is calculated to check the solution at updated temperature if smaller function value then points is accepted otherwise discarded this process now carries for more iteration or just n iterations and sufficient low-temperature point we get [29].

4.15 Water Cycle (WC)

WC is under classification category of non-living intelligence. The algorithm basically uses nature's water cycle and sees how they are being used to give the optimization result. The algorithm consists of different stages, namely (i) Precipitation—this process can be linked to random initialization of population, (ii) Percolation into the sea this can be linked to that population is meant to be attracted toward the best solution, (iii) Evaporation, followed by precipitation—this step can be linked to the stage where reinitialization of the same solution is done. So this is how it be used to find the best solution [30] (Table 1).

5 Conclusion

The severity of a brain tumor depends upon its detection stage. If detected in its initial stage, most brain tumors are curable and have more survival rates than usual. This paper gives a review of the metaheuristic optimization-based CAD system which helps in better detection of brain tumors. The paper provides the study of popularly used metaheuristic techniques which are used in detecting brain tumor from brain MRI. A comparison table is included to provide significant improvement in parameters like accuracy, better precision, segmented result and overall more robust system after comparison of different metaheuristic techniques with other methods or techniques. However, there is still research going on to develop faster and accurate CAD system as these methods have some limitations which can be removed. Hence, the detailed knowledge of metaheuristic optimization techniques, their advantages and recent studies in the field of brain tumor detection will help to develop an improved CAD system that provides aid to doctors and assist them to give an accurate detection result.

Table 1 Overview of papers using metaheuristic techniques for brain tumor prediction

Ref.	Dataset used	Method used	Proposed solution	Improved parameters	Year	Performance measure values
[1]	9 MR images	GA, FCM, K-means	ABC-based clustering method	Clustering quality increased	2013	CS -0.6 approx
[2]	Real MR image	GA	ACO (proposed segmentation based)	Accuracy increased segmentation is improved	2009	Pictorial results are mentioned
[3]	MR images (BRATS)	Bat algorithm + active contour segmentation method	None	Overall precision, sensitivity, specificity and accuracy increases	2017	Accuracy-0.96 Precision-0.99 Specificity-0.93 Sensitivity-0.9972
[4]	200 MR images (MBIC)	ABC, bacteria foraging optimization	Cuckoo search (segmentation based)	Increased accuracy, sensitivity and specificity	2015	Accuracy-0.98 Specificity-0.933 Sensitivity-0.988
[5]	Colored MRI (www.scienceph oto.com)	DE (Different variants)	Transformed (DE)	Computational time reduced and resultant image quality improved	2019	Image = 3 No. of threshold = 4 PSNR = 15.23 CPU Time = 5.4
[6]	50 real MR images, T1 weighted	Different kernel SVM (Linear, RBF, Quadratic)	FA	Percentage of tumor detection increases, delay time reduced, False Positive Rate (fpr) increases	2008	Accuracy-0.73 FPR-3.16 % of tumor-1.40 Delay time-0.019
[7]	T2 weighted MRI	K-means, KFCM	Dynamic GA	Standard deviation is decreased	2016	Accuracy-0.995
[8]	5 low-contrast brain MRI	GA, PSO, CS	GWO	PSNR increases, MSE decreases, computation time reduced	2014	PSNR-16.19 MSE-1563.353 Time-85.021 (data is based on one of 5 low-contrast image)
[9]	MR image (SBD)	FCM and other methods	HS + dynamic fuzzy clustering	Better segmented output	2011	Minkowski Score(MS)-0.45 to 0.75(ideal value is 0)
[10]	400 MRI (JMRIDCE)	(i) DWT + PCA + ANN (ii) GLCM + Neuro fuzzy classifier etc.	Hybrid Krill Herd ELM extreme machine	Accuracy, specificity, sensitivity are increased	2018	Accuracy-0.989 Specificity-0.975 Sensitivity-0.985

(continued)

Table 1 (continued)

Ref.	Dataset used	Method used	Proposed solution	Improved parameters	Year	Performance measure values
[11]	3D MRI BRATS	FCM, SVM, Random forest	LS + Dragon fly algorithm	Accuracy, precision and recall improved	2020	Accuracy-0.982 Recall-0.951 Precision-0.932
[12]	T1, T2 MRI dataset (BRATS)	(i) PSO-FCM (ii) Cuckoo-IT2FCM	Modified monkey search	Dice overlap index (DOI) increases, sensitivity increases, computation time is less	2020	DOI –0.953 Time-1.194 Sensitivity-0.9912
[13]	50 MRI (BRATS)	K-means + DWT + KSVM	PSO	Sensitivity increases	1995	Sensitivity-0.954
[14]	MR images from Harvard medical school	GA	SA	Accuracy increases	1970	Accuracy-0.956
[15]	Grayscale MRI	ANN, without optimization	Convolution WCA	Accuracy, sensitivity, specificity, PSNR value increases	2020	Accuracy-0.965 Specificity-0.965 Sensitivity-0.966

BRATS Brain Tumor Segmentation, *MBIC* McConnell BrainImaging Center, *JMRIDC* Jason MRI Diagnostic Center Erode, *SBD* Brain Web Simulated Brain Database

6 Future Scope

It is discussed that metaheuristic optimization algorithms are widely used in complex optimization problems, along with various studies that these algorithms have some limitations like less mathematical nature, which makes it difficult to derive exact theory behind them. It is also observed that some algorithms which are developed in recent years have some similarity between them like those of harmony search algorithm which has a similarity with evolutionary algorithm strategy, etc. which leads to development of unnecessary new algorithms. So, there is a need of future research which helps to rectify the problem of mathematical analysis and novelty of different algorithms. This paper tries to provide a generic framework which relates and fits these metaheuristic algorithms under one framework. The same can be tried in future research by providing the general framework of these types of algorithms.