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Research paper

Historical survey on metaheuristics algorithms

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Abstract

Metaheuristic algorithms have been an interesting and widely used area for scientists, researchers and academicians because of their specific and significant characteristics and capabilities in solving optimization problems. Metaheuristic algorithms are developed base on inspiration of some real world phenomenon in nature or on the behavior of living being (animal, insects, organic living beings). On the past many metaheuristic algorithms have been introduced and applied on various problems of various domains including real world optimization problems. This paper is aimed to provide a historical Survey on metaheuristic algorithms, it will provide a list of metaheuristic based algorithms ordered according to the foundation year, with the name of Authors and the algorithm abbreviations.

Keywords: *Metaheuristic; Swarm Intelligence; History; Natural Inspired Algorithm; Optimization Algorithms; Classifications*

1. Introduction

Generally the complexity of the real life problems are in increasing in a manner that it become Difficult for the traditional mathematical programming methods to solve and optimize them. Most of the real-life optimizations problems are nonlinear, complex, multimodal, and they have a incompatible objectives functions in which the process of obtaining an optimal or even near-optimal solutions is a very difficult task, even for a single easy and linear objective functions, sometimes, an optimal solutions may not exists at all, generally, there is no guarantee of getting an optimal solution for real-life problems [1] [2].
Over the past years, Metaheuristics Optimization Algorithms become a very active area of researches and one of the most well known high-level procedure designed for generating, selecting or finding a heuristic that optimize solutions and provide a sufficiently better, improved and fittest solutions to a given objective functions for a real-life optimization problem [3] [4].
In this paper we will present a number of metaheuristics algorithm according to the year of its appearance.

2. Metaheuristic algorithms

In the past the methods that have a stochastic mechanisms often called heuristic algorithm, nowadays in the recent studies it refer to as metaheuristics which is a combination of two words Meta and Heuristic, were the world “heuristic” means finding or discovering a goal by trial and error, and the world “meta” means a beyond or higher level, that means a metaheuristics generally refers a “higher level of heuristics” [5]. generally metaheuristic algorithms represent as a "master strategy that guides and modifies other heuristics to produce solutions beyond those that are normally generated in a quest for local optimality" [6]. Those algorithms use a certain adjustment of randomization and local search. A good solutions for difficult optimization problems can be found in a reasonable time, but in general there is no guarantee of finding optimal solutions[1 - 4].
In the fields of computer science, mathematical optimizations and engineering’s, the term “metaheuristic” represents a higher-level procedure or heuristic designed to search, find, generate, or select a heuristics, that may provide a good solution to an optimization problem, especially for the large problems such as (NP-hard problem) or incase of limit, incomplete or imperfect information[1]. Metaheuristics consists of a set of solutions which is too large to be completely sampled. Metaheuristics may make few assumptions about the optimization problem being solved, and so they may be usable for a variety of problems. [199].
Compering with optimization algorithms or iterative methods, metaheuristics do not guarantee that the best solution a globally optimal solution can be found on some class of problems [3]. Many metaheuristics implement some form of stochastic optimization, so that the solution found is dependent on the set of random variables generated [2]. In combinatorial optimization, by searching over a large set of feasible solutions, metaheuristics can often find good solutions with less computational effort than optimization algorithms, iterative methods, or simple heuristics. As such, they are useful approaches for optimization problems [2].
Most literature on metaheuristics is experimental in nature, describing empirical results based on computer experiments with the algorithms. But some formal theoretical results are also available, often on convergence and the possibility of finding the global optimum. Many metaheuristic methods have been published with claims of novelty and practical efficacy. While the field also features high-quality

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research, many of the publications have been of poor quality; flaws include vagueness, lack of conceptual elaboration, poor experiments, and ignorance of previous literature.
These are properties that characterize most metaheuristics:

- Metaheuristics are strategies that guide the search process.
- The goal is to efficiently explore the search space in order to find near–optimal solutions.
- Techniques which constitute metaheuristic algorithms range from simple local search procedures to complex learning processes.
- Metaheuristic algorithms are approximate and usually non-deterministic.
- Metaheuristics are not problem-specific.

3. Metaheuristic algorithms major components:

Generally metaheuristic algorithms contains two major components:

- Intensification
- Diversification

Diversifications means generating a diverse solutions so as to explore the search-space on a global scale, and the Intensification means focusing the search in a local-region that significantly believed that a current-good solution may be found in this region [7].
Balancing between those two components in the process of selecting the best-solutions improves the quality of algorithm convergence and ensures that solutions will converge to the optimum [7].

4. Metaheuristic algorithms classifications

Metaheuristics are broadly classified into two categories (single solution and population based) algorithms. Single solution based algorithms are those in which a solution is randomly generated and improved until the optimum result is obtained, whereas population based algorithms are those in which a set of solutions are randomly generated in a given search space and solution values are updated during iterations until the best solution is generated [2] , figure 1 shows the metaheuristic classifications.
However, single solution based algorithms may trap into local optima which may prevent us to find global optimum as it reforms only one solution, which is randomly generated for a given problem. On the other hand, population based algorithms have an inherent ability to escape local optima [2]. Due to this, nowadays, population based algorithms have gained the attention of multitudinous researchers.
The categorization of population based algorithms is done on the basis of theory of evolutionary algorithms [201], physics laws based algorithms, swarm intelligence of particles, and biological behavior of bio-inspired algorithms. Evolutionary algorithms are inspired by the evolutionary processes such as reproduction, mutation, recombination, and selection. These algorithms are based on the survival fitness of candidate in a population (i.e., a set of solutions) for a given environment. The physics law based algorithms are inspired by physical processes according to some physics rules such as gravitational force, electromagnetic force, inertia force, heating and cooling of materials. Swarm intelligence based algorithms are inspired by the collective intelligence of swarms[8].
Some of the most popular evolutionary algorithms are Genetic Algorithms (GA) [6] [203], Evolution Strategy (ES) [7], Differential Evolution (DE) [8] [202], and Biogeography-Based Optimizer (BBO) [9].
A well-known algorithm of swarm intelligence technique is Particle Swarm Optimization (PSO) [10,11] [203], Elephant Herding Optimization (EHO) [202]. PSO is inspired by the social behavior of fish schooling or bird flocking. Each particle can move around the search space and update its current position with respect to the global best solution.

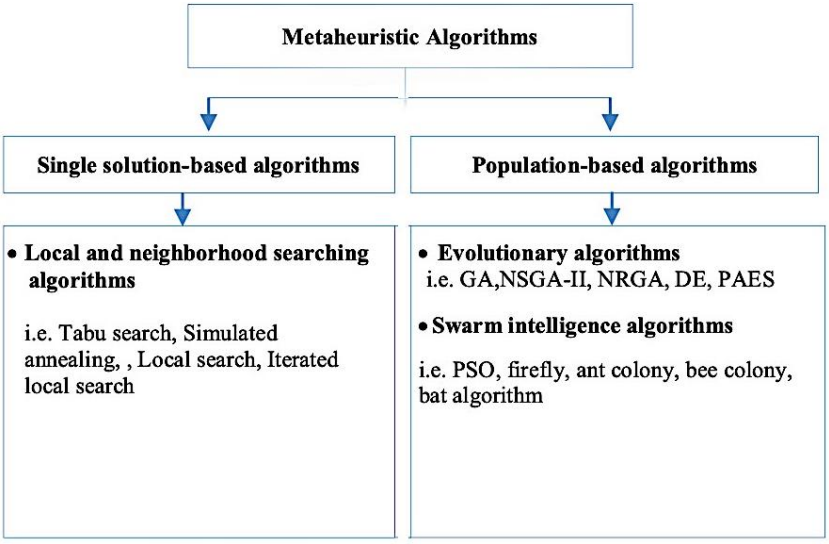

Fig. 1: Metaheuristic Classifications.

4.1. Evolutionary algorithms (EA)

Evolutionary algorithms (EAs) are the most well known, traditional and established algorithms between the nature inspired algorithms, inspired from the biological evolution in nature. In the passed year EA are extensively used for solving various specializations of science and real-time applications to find an optimum solution for complex and optimization problems [201] The word Evolutionary algorithm is used to define a collection of optimization techniques that simulate the natural biological evolution and the social behavior of living species. Differential Evolution (DE), Evolutionary strategy (ES), Genetic algorithm (GA), Genetic programming (GP), and Granular Agent Evolutionary Algorithm are the most well-known Algorithms belongs to Evolutionary algorithms (EAs) [201] [202].

4.2. Swarm intelligence (SI)

In computer sciences, Swarm Intelligence (SI) is the field of studying and designing efficient computational methods to solve problems using the behavior of real swarms such as birds, fish, and ants [1][2][201]. SI is a part of Artificial Intelligence introduced in the global optimization framework in 1989 by Jing Wang and Gerardo Beni as a collection of algorithms for controlling robotic swarm [1][2].
Swarm Intelligence issued a number of homogenous agents which interacts with each other either directly or indirectly, they communicate directly with each other by using audio or visual tools, as the honey bees communicate by waggle dance; indirect communication refers to as stigmergy [1][2][3][202]. Grasse first introduced the concepts stigmergy to the processes when an insect makes change in the. environment around it, and the other insects respond to that change and adapt themselves. to the new environment, such as in ant colonies when an ant deposit pheromone in its way to the food, leads other ants to follow that way Examples of swarm intelligence methods are Ant Colony Optimization (ACO), Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO), Bacterial Foraging, Artificial Immune System, Stochastic diffusion search, Cat Swarm Optimization, Gravitational search algorithm, Bat algorithm, and Glowworm Swarm Optimization [1][2][3][201].

4.3. Local search methods

Local search metaheuristics refers to a group of methods which depend on a neighborhood, which are a set of candidate states, that are connected directly to the current state and can be reached by a single move for finding a best solution for computationally hard optimization problems. Its methods are iteratively improve the ordering of current solution states by performing simple modifications on the current solutions to obtain a new solution, the improvement continues until some stopping conditions has been satisfied or when there is no better solution in the given neighborhood [2].
The most famous and widely used Local search algorithms is k-opt which takes an initial tour and improves it by making flips in the tour to obtain a better tour, it is the basics of 2-opt, 3-opt, and Lin-Kernighan (LK)[2]. A more complicated local search method that could have other Local search method imbedded inside it, is called Great Deluge Algorithm (GDA), its procedure is finding a better solution from the neighborhood of the initial solution, and then it iteratively improving solution. Another local search method which is based on Hill-Climbing, includes some kind of intelligent in it, and is known as Tabu Search (TS), its procedure based on saving the previous moves in a list called "tabu list" which is used to avoid cycling. Many other local search algorithms are used in computer field to escape from local optimality which take unbounded time, one of the most known algorithms is Simulated annealing (SA) [2].

5. Historical study

In the history Several problem-solving technique tend to be metaheuristic; however heuristic as a scientific technique for optimization is a modern phenomenon. Metaheuristic algorithm or heuristic algorithm are developed in different historical periods.
Between 1940s and 1960s, heuristic methods widely used in different applications, but the main achievement was in 1963 with the introduction of evolutionary algorithms (EA) by I. Rechenberg and H. Schwefel [9].
Between 1960s and 1970s, saw the development of Genetic algorithms by J. Holland in 1975 [10].
Between 1980s and 1990s found one of the biggest step in the metaheuristics algorithms which was the simulated annealing (SA) in 1983 by S. Kirkpatrick, D. Gelatt Jr., and M. P. Vecchi [11]. Another significant step was the development of artificial immune systems in 1986 by Farmer, Packard and Perelson [12].
in the 1986, for the first time memory was used in metaheuristics by Fred Glover in Tabu search (TS) algorithm in which the previous search moves are stored in a Tabu-list, and upcoming moves must avoid revisiting previous moves [13].
Between 1990s and 2000s, was an exciting period for metaheuristic algorithms, as it saw the development of several important algorithms such as ant colony optimization (ACO) by Marco Dorigo in 1992 [7, 1, 4], and particle swarm optimization (PSO) by James Kennedy and Russell C. Eberhart in 1995 [1, 2, 3, 14], and later differential evolution (DE) was developed by Storn, R.; Price, K in 1997 [15].
Form 2000 until nowadays, metaheuristic algorithms has widely used in many applications, and many new significant algorithms has been developed. In 2001 Zong Woo Geem, Joong Hoon Kim, and G. V. developed the harmony search (HS) algorithm [16]. in 2002, a bacteria foraging algorithm was developed by K.M. Passino [17].
in 2005 D. Karaboga developed the artificial bee colony (ABC). In 2009, Xin-She Yang and Suash Deb developed cuckoo search (CS) algorithm [18].
Generally there are many significant metaheuristic algorithms that have been developed to solve real life and optimizations problems [3] [4]. Table 1: Shows Some of Metaheuristic Algorithms with Its Authors Name and Establishing Year.

Table 1: List of Metaheuristic Algorithms.

ID	Year	Algorithm Name	Abbreviation	Authors	References
1.	1961	Pattern Search	PS	R. Hooke, T. A. Jeeves	[19]
2.	1963	evolutionary algorithms	EA	Rechenberg & Schwefel	[9]
3.	1965	Evolution Strategy	ES	Rechenberg & Schwefel	[9]
4.	1966	Evolutionary Programming	EP	David B. Fogel, Lawrence J. Fogel	[20]
5.	1975	Genetic Algorithm	GA	John Holland	[10] [203]
6.	1977	Scatter Search	SS	F. Glover	[21]
7.	1983	Simulated Annealing	SA	S. Kirkpatrick, D. Gelatt Jr., and M. P. Vecchi	[11]
8.	1986	Tabu Search	TS	Fred Glover	[13] [2] [203]
9.	1986	artificial immune systems	AIS	Farmer, Packard and Perelson	[12]
10.	1989	Stochastic Diffusion Search	SDS	Bishop, J.M.	[22]
11.	1989	Memetic Algorithm	MA	Moscato	[23]
12.	1992	Ant Colony Optimization	ACO	A. Colorni, M. Dorigo, V. Maniezzo	[2] [24]
13.	1993	Great Deluge Algorithm	GDA	G. Dueck	[2] [25] [195]
14.	1995	Particle Swarm Optimization	PSO	R. Eberhart, J. Kennedy	[3] [14][203]
15.	1997	Differential Evolution	DE	Storn, R.; Price, K	[15]
16.	1998	Photosynthetic Learning Algorithm	PLA	Haruhiko Murase, Akira Wadano	[26]

17.	2000	Clonal Selection Algorithm	CSA	L.N. de Castro, F.J. von Zuben	[27]
18.	2001	Harmony Search	HS	Zong Woo Geem, Joong Hoon Kim, and G.V.	[16]
19.	2001	Honey-bees Mating Optimization Algorithm	HBMOA	H.A. Abbass	[28]
20.	2001	POPMUSIC: Partial Optimization Metaheuristic Under Special Intensification	POPMUSIC	Éric D. Taillard, Stefan Voss	[29]
21.	2001	Sheep Flocks Heredity Model	SFHM	Hyunchul Kim and Byungchul Ahn	[30]
22.	2002	Artificial Fish School Algorithm	AFS	X.L. Li, Z.J. Shao and J.X. Qian	[31]
23.	2002	Bacteria Chemotaxis Algorithm	BCA	S.D. Muller, J. Marchetto , S. Airaghi and P. Kournoutsakos, 2002	[32]
24.	2002	Bacterial Foraging Algorithm	BFA	K.M. Passino	[17]
25.	2002	Gene Expression Programming		C. Ferreira	[33]
26.	2002	Social Cognitive Optimization	SCO	Xiao-Feng Xie, Wen-Jun Zhang, Zhi-Lian Yang	[34]
27.	2002	Bacterial Foraging Optimization	BFO	Passino	[35]
28.	2003	Shuffled Frog Leaping Algorithm	SFL	Eusuff and K.E. Lansey	[36]
29.	2003	Gravitational Search Algorithm	GSA	B. Webster and P.J. Bernhard	[37]
30.	2003	Queen-bee Evolution	GBE	S.H. Jung	[38]
31.	2003	Society and Civilization	SC	Ray, Tapabrata, and Kim Meow Liew	[39]
32.	2003	Fish Swarm Algorithm	FSA	Li, Shao, Qian	[40]
33.	2005	Wasp Swarm Optimization	WSO	P Pinto, TA Runkler, JM Sousa	[41]
34.	2006	Big bang-big Crunch	BBBC	Osman K. Erol and Ibrahim Eksin	[42]
35.	2006	Cat Swarm Optimization	CSO	Shu-Chuan Chu, Pei-Wei Tsai, and Jeng-Shyang Pan	[43]
36.	2006	Covariance Matrix Adaptation-Evolution Strategy	CMAES	Nikolaus Hansen, Sibylle D. Müller and Petros Koumoutsakos	[44]
37.	2006	Invasive Weed Optimization	IWO	A.R. Mehrabian, C. Lucas	[45]
38.	2006	Saplings Growing Up Algorithm	SGUO	Ali Karci, Bilal Alatas	[46]
39.	2006	Small-world Optimization Algorithm	SWOA	H Du, X Wu, J Zhuang	[47]
40.	2006	Invasive Weed Colony Optimization	IWCO	Mehrabian, Lucas	[48]
41.	2006	Group Search Optimization	GSO	He, Wu, Saunders	[49]
42.	2007	Artificial Bee Colony Algorithm	ABC	Dervis Karaboga and Bahriye	[3] [50]
43.	2007	Central Force Optimization	CFO	Richard A. Formato	[51]
44.	2007	Good Lattice Swarm Algorithm	GLSA	Shoubao Su, Jiwen Wang, Wangkang Fan, Xibing Yin	[52]
45.	2007	Imperialist Competitive Algorithm	ICA	Esmaeil Atashpaz-Gargari and Caro	[53]
46.	2007	Monkey Search	MS	Antonio Mucherino and Onur Seref	[54]
47.	2007	Parliamentary Optimization Algorithm	POA	A. Borji	[55]
48.	2007	River Formation Dynamics	RFD	P. Rabanal, I. Rodríguez, F. Rubio	[56]
49.	2007	Simplex Heuristic	SH	J.P. Pedroso	[57]
50.	2008	Bacterial Swarming	BS	Ying Chu, Hua Mi and Huilian Liao	[58]
51.	2008	Biogeography Based Optimization	BBO	Ying Chu, Hua Mi and Huilian Liao	[59]
52.	2008	Fish-school Search	FS	Carmelo J. A. Bastos Filho , Fernando B. de Lima Neto, Anthony J. C. C. Lins, Antonio I. S. Nascimento, Marilia P. Lima	[60]
53.	2008	Plant Growth Optimisation	PGO	Wei Cai, Weiwei Yang and Xiaoqian Chen	[61]
54.	2008	Roach Infestation Optimization	RIO	Timothy C. Havens, Christopher J. Spain, Nathan G. Salmon and James M. Keller	[62]
55.	2008	Viral Systems	VS	Cortés P., García J.M., Muñuzuri J. and Onieva L0	[63]
56.	2009	Artificial Searching Swarm Algorithm	ASSA	T. Chen	[64]
57.	2009	Bacterial Evolutionary Algorithm	BEA	Swagatam Das , Archana Chowdhury and Ajith Abraham	[65]
58.	2009	Consultant-guided Search	CGS	S. Iordache	[66]
59.	2009	Dialectic Search	DS	S Kadioglu, Meinolf Sellmann	[67]
60.	2009	Dolphin Partner Optimization	DPO	Y Shiqin, J Jianjun, Y Guangxing	[68]
61.	2009	Firefly Algorithm	FA	Xin-She Yang	[69]
62.	2009	Glowworm Swarm Optimization	GSO	K. N. Krishnanand and Debasish Ghose	[70]
63.	2009	Group Search Optimizer	GSO	S. He, Q.H. Wu, J.R. Saunders	[71]
64.	2009	Human-inspired Algorithm	HIA	L.M. Zhang, C. Dahlmann, Y. Zhang	[72]
65.	2009	Hunting Search	HS	R. Oftadeh , M. J. Mahjoob	[73]
66.	2009	Intelligent Water Drops Algorithm	IWDA	Hamed Shah-Hosseini	[74]
67.	2009	League Championship Algorithm	LCA	Ali Husseinzadeh Kashan	[75]
68.	2009	Locust Swarms	LS	Stephen Chen	[76]
69.	2009	Paddy Field Algorithm	PFA	U. Premaratne, J. Samarabandu, T. Sidhu	[77]
70.	2009	Bumble Bees Mating Optimization	BBMO	Marinakis, Marinaki, Matsatsinis	[78]
71.	2009	Hunting Search Optimization	HSO	Oftadeh, Mahjoob	[79]
72.	2009	Cuckoo Search	CS	Yang, Deb	[18]
73.	2010	Bat Algorithm	BA	Xin-She Yang	[3] [80]
74.	2010	Charged System Search	CSS	A. Kaveh, and S. Talatahari	[81]
75.	2010	Eagle Strategy	ES	X.S. Yang, S. Deb	[82]
76.	2010	Fireworks Algorithm	FA	Y. Tan, Y. Zhu	[83]
77.	2010	Grenade Explosion Method	GEM	Ali Ahrari and Ali A. Atai	[84]
78.	2010	Group Counseling Optimization	GCO	M.A. Eita and M. M. Fahmy	[85]
79.	2010	Hierarchical Swarm Model	HSM	Hanning Chen, Yunlong Zhu, Kunyuan Hu and Xiaoxian He	[86]
80.	2010	Reincarnation Algorithm	RA	A. Sharma	[87]
81.	2010	Social Emotional Optimization	SEO	Y. Xu, Z. Cui, J. Zeng	[88]

82.	2010	Termite Colony Optimization	TCO	Ramin Hedayatzadeh, Foad Akhavan Salmassi, Reza Akbari, Koorush	[89]
83.	2010	Wind Driven Optimization	WDO	Zikri Bayraktar, Muge Komurcu, and Douglas H. Werner	[90]
84.	2010	Bat Inspired Approach	BIA	Yang	[91]
85.	2011	Artificial Chemical Reaction Optimization Algorithm	ACROA	Bilal Alatas	[92]
86.	2011	Eco-inspired Evolutionary Algorithm	EIEA	R.S. Parpinelli, H.S. Lopes	[93]
87.	2011	Galaxy-based Search Algorithm	GBS	Hamed Shah-Hosseini	[94]
88.	2011	Migrating Birds Optimization	MBO	Ekrem Duman, Mitat Uysal, Ali Fuat Alkaya	[95]
89.	2011	Plant Propagation Algorithm	PPA	Abdellah Salhi, Eric S Fraga	[96]
90.	2011	Spiral Dynamics Inspired Optimization	SDIO	K. Tamura, K. Yasuda	[97]
91.	2011	Teaching-learning based Optimization	TLBO	R. V. Rao, V. J. Savsani, D. P. Vakharia	[98]
92.	2011	Water-flow Algorithm	WFA	Trung Hieu Tran, Kien Ming Ng	[99]
93.	2012	Anarchic Society Optimization	ASO	H. Shayeghi and J. Dadashpour	[100]
94.	2012	Artificial Plant Optimization Algorithm	APO	Jun Li, Zhihua Cui and Zhongzhi Shi	[101]
95.	2012	Bacterial Colony Optimization	BCO	Ben Niu and Hong Wang	[102]
96.	2012	Community of Scientist Optimization	CSO	Alfredo Milani and Valentino Santucci	[103]
97.	2012	Differential Search Algorithm	DF	P. Civicioglu	[104]
98.	2012	Electro-magnetism Optimization	EM	Erik Cuevas, Diego Oliva , Daniel Zaldivar, Marco Pérez-Cisneros, Humberto	[105]
99.	2012	Flower Pollination Algorithm	FPA	Xin-She Yang	[106]
100.	2012	Fruit Fly Optimization Algorithm	FFO	W. T. Pan	[107]
101.	2012	Great Salmon Run	GSR	A. Mozaffari, A. Fathi, S. Behzadipour	[108]
102.	2012	Hoopoe Heuristic Optimization	HHO	Mohammed El-Dosuky, Ahmed El-Bassiouny, Taher Hamza, and Magdy Rashad	[109]
103.	2012	Japanese Tree Frogs Calling	JTFC	H. Hernández, C. Blum	[110]
104.	2012	Krill Herd	KH	Amir Hossein Gandomi and Amir Hossein Alavi	[111]
105.	2012	Mine Blast Algorithm	MBA	Ali Sadollah, Ardeshir Bahreininejad, Hadi Eskandar, Mohd Hamdi (	[112]
106.	2012	Ray Optimization	RO	A. Kaveh and M. Khayatazad	[113]
107.	2012	Soccer Game Optimization	SGO	H.D. Purnomo, H.-M. Wee	[114]
108.	2012	Water Cycle Algorithm	WCA	Hadi Eskandar, Ali Sadollah, Ardeshir Bahreininejad, Mohd Hamdi,	[115]
109.	2012	Wolf Search Algorithm	WF	Rui Tang, S. Fong, Xin-She Yang, and S. Deb	[116]
110.	2012	Zombie Survival Optimization	ZSO	Hoang Thanh Nguyen, Bir Bhanu	[117]
111.	2012	Collective Animal Behavior	CBA	Cuevas,_González, Zaldivar, Pérez-Cisneros,_ García_ _	[118]
112.	2013	Dolphin Echolocation	DE	A. Kaveh, N. Farhoudi	[119]
113.	2013	African Wild Dog Algorithm	AWD	C. Subramanian , A.S.S. Sekar and K. Subramanian	[120]
114.	2013	Atmosphere Clouds Model	ACM	Gao Wei Yan and Zhan Ju Hao	[121]
115.	2013	Backtracking Search Optimization	BSO	Pinar Civicioglu	[122]
116.	2013	Black Holes Algorithm	BHA	Abdolreza Hatamlou	[123]
117.	2013	Blind, Naked Mole-rats Algorithm	BNMR	Mohammad Taherdangkoo, Mohammad Hossein Shirzadi , Mehran Yazdi and Mohammad Hadi Bagheri	[124]
118.	2013	Cuttlefish Algorithm	CFA	Adel Sabry Eesa, Adnan Mohsin Abdulazeez Brifcani and Zeynep Orman	[125]
119.	2013	Egyptian Vulture Optimization	EVO	Chiranjib Sur, Sanjeev Sharma, and Anupam Shukla	[126]
120.	2013	Gases Brownian Motion Optimization	GBMO	M. Abdechiri, M.R. Meybodi, H. Bahrami	[127]
121.	2013	Magnetotactic Bacteria Optimization Algorithm	MBOA	Hongwei Mo and Lifang Xu	[128]
122.	2013	Penguins Search Optimization Algorithm	PSOA	Y. Gheraibia, A. Moussaoui	[129]
123.	2013	Seven-spot Ladybird Optimization	SLO	Peng Wang, Zhouquan Zhu, and Shuai Huang	[14]
124.	2013	Social Spider Algorithm	SSA	Erik Cuevas, Miguel Cienfuegos, Daniel Zaldívar , Marco Pérez-Cisneros	[130]
125.	2013	Swallow Swarm Optimization Algorithm	SSO	Mehdi Neshat, Ghodrat Sepidnam	[131]
126.	2014	Animal Migration Optimization Algorithm	AMO	Xiangtao Li, Jie Zhang and Minghao Yin	[132]
127.	2014	Artificial Ecosystem Algorithm	AEA	Manal T. Adham and Peter J. Bentley	[133]
128.	2014	Bird Mating Optimizer	BMO	Alireza Askarzadeh	[134]
129.	2014	Chicken Swarm	CS	Xianbing Meng, Yu Liu, Xiaozhi Gao, Hengzhen Zhang	[135]
130.	2014	Cockroach Swarm Optimization	CSO	I. C. Obagbuwa and A. O. Adewumi	[136]
131.	2014	Colliding Bodies Optimization	CBO	A. Kaveh and V. R. Mahdavi	[137]
132.	2014	Coral Reefs Optimization Algorithm	CRO	S. Salcedo-Sanz, J. Del Ser, I. Landa-Torres, S. Gil-López, and J. A. Portilla-Figueras	[138]
133.	2014	Exchange Market Algorithm	EMA	N. Ghorbani, E. Babaei	[139]
134.	2014	Forest Optimization Algorithm	FOA	Manizheh Ghaemi, Mohammad-Reza Feizi-Derakhshi	[140]
135.	2014	Golden Ball	GB	E. Osaba, F. Diaz, E. Onieva	[141]
136.	2014	Greedy Politics Optimization	GPO	J.M.L. Melvix	[142]
137.	2014	Grey Wolf Optimizer	GWO	Seyedali Mirjalili, Seyed Mohammad Mirjalili, and Andrew Lewis	[143]

138.	2014	Heart	H	Abdolreza Hatamlou	[144]
139.	2014	Interior Design and Decoration	IDD	A.H. Gandomi	[145]
140.	2014	Kaizen Programming	KP	V. V. Melo	[146]
141.	2014	Keshtel Algorithm	KA	M. Hajiaghaei-Keshteli, M. Aminnayeri	[147]
142.	2014	Raven Roosting Optimization Algorithm	RROA	Anthony Brabazon, Wei Cui, Michael O'Neill	[148]
143.	2014	Scientific Algorithms for the Car Renter Salesman Problem		D. Felipe, E. Goldbarg, and M. Goldbarg	[149]
144.	2014	Shark Smell Optimization	SSO	Oveis Abedinia, Nima Amjady, and Ali Ghasemi	[150]
145.	2014	Spider Monkey Optimization	SMO	Jagdish Chand Bansal, Harish Sharma, Shimpi Singh Jadon, Maurice Clerc	[151]
146.	2014	Strawberry Algorithm	SA	F. Merrikh-Bayat	[152]
147.	2014	Symbiotic Organisms Search	SOS	M.Y. Cheng, D. Prayogo	[153]
148.	2014	Worm Optimization	WO	J.P. Arnaout	[154]
149.	2015	Ant Lion	AL	S. Mirjalili	[155]
150.	2015	Artificial Algae Algorithm	AAA	Sait Ali, Uymaz, GulayTezel and Esra Yel	[156]
151.	2015	U-Turning Ant Colony Optimization	U-TACO	Saman M. Almufti	[2][4][202][203]
152.	2015	Brain Storm Optimization	BSO	Y. Shi	[157]
153.	2015	Bull Optimization Algorithm	BOA	Sait Ali, Uymaz, GulayTezel and Esra Yel	[158]
154.	2015	Elephant Herding Optimization	EHO	Gai-Ge Wang, Suash Deb, Leandro dos S. Coelho	[1] [159][202]
155.	2015	Elephant Search Algorithm	ESA	Suash Deb, Simon Fong, and Zhonghuan Tian	[160]
156.	2015	General Relativity Search Algorithm	GRSA	Hamzeh Beiranvand, Esmaeel Rokrok	[161]
157.	2015	Invasive Tumor Growth Optimization Algorithm	ITGOA	D Tang, S Dong, Y Jiang, H Li, Y Huang	[162]
158.	2015	Ions Motion Algorithm	IMA	B. Javidy, A. Hatamlou, S. Mirjalili	[163]
159.	2015	Jaguar Algorithm with Learning Behavior	JA	Chin-Chi Chen, Yung-Che Tsai, I-I Liu, Chia-Chun Lai, Yi-Ting Yeh, Shu-Yu Kuo, Yao-Hsin Chou	[164]
160.	2015	Lightning Search Algorithm	LSA	H. Shareef, A.A. Ibrahim, A.H. Mutlag	[165]
161.	2015	Monarch Butterfly Optimization	MBO	G. Wang, S. Deb, Z. Cui	[166]
162.	2015	Moth-flame Optimization Algorithm	MFOA	Seyedali Mirjalili	[167]
163.	2015	Multi-verse Optimizer	MVO	S. Mirjalili, S. M. Mirjalili, A. Hatamlou	[168]
164.	2015	Optics Inspired Optimization	OIO	A.H. Kashan	[169]
165.	2015	Root Growth Optimizer	RGO	Xiaoxian Hea , Shigeng Zhang , Jie Wang	[170]
166.	2015	Runner-root Algorithm	RRA	F. Merrikh-Bayat	[171]
167.	2015	Stochastic Fractal Search	SFS	H. Salimi	[172]
168.	2015	Vortex Search Algorithm	VSA	B. Dogan, T. Olmez	[173]
169.	2015	Water Wave Optimisation	WWO	Y.J. Zheng	[174]
170.	2016	African Buffalo Optimization	ABO	J.B. Odili and M.N. Mohmad Kahar	[175]
171.	2016	Bird Swarm	BS	Xian-Bing Meng, X.Z. Gao, Lihua Lu, Yu Liu & Hengzhen Zhang	[176]
172.	2016	Camel Algorithm	CA	M. K. Ibrahim, R. S. Ali	[177]
173.	2016	Crystal Energy Optimization Algorithm	CEOA	X. Feng, M. Ma, and H. Yu	[178]
174.	2016	Dragonfly Algorithm	DA	S. Mirjalili	[179]
175.	2016	FIFA World Cup	FWC	N. Razmjooy, M. Khalilpour, M. Ramezani	[180]
176.	2016	Flying Elephants Algorithm	FEA	Adilson Elias Xavier, Vinicius Layter Xavier	[181]
177.	2016	Lion Optimization Algorithm	LOA	Maziar Yazdani and Fariborz Jolai	[182]
178.	2016	Rooted Tree Optimization Algorithm	RTOA	Yacine Labbi, Djilani Ben Attous, Hossam A. Gabbar, Belkacem Mahdad, Aboelsood	[183]
179.	2016	Sperm Whale Algorithm	SWA	A. Ebrahimi, E. Khamehchi	[184]
180.	2016	Virus Colony Search	VCS	Mu Dong Li, Hui Zhao, Xing Wei Weng, Tong Han	[185]
181.	2016	Virus Optimization Algorithm	VOA	Chia Liang, Josue Rodolfo Cuevas	[186]
182.	2016	Water Evaporation Optimization	WEO	A. Kaveh and T. Bakhshpoori	[187]
183.	2016	Whale Optimization Algorithm	WOA	Seyedali Mirjalili and Andrew Lewisa	[188]
184.	2017	Grasshopper Optimisation Algorithm	GOA	Shahrzad Saremi, Seyedali Mirjalili, Andrew Lewis	[189]
185.	2017	Sperm Motility Algorithm	SMA	Raouf, Hezam	[190]
186.	2017	Rain Water Algorithm	RWA	Biyanto, T R; Matradji; Syamsi, M N; Fibrianto, H Y; Afdanny, N; Rahman, A H; Gunawan, K S; Pratama, J A D; Malwindasari, A; Abdillah, A I; Bethiana, T N; Putra, Y A	[195]
187.	2017	Hydrological Cycle Algorithm	HCA	Wedyan, Ahmad; Whalley, Jacqueline; Narayanan, Ajit	[197]
188.	2018	Farmland fertility	FF	H Shayanfar, F Gharehchopogh	[191]
189.	2019	The Sailfish Optimize	TSO	S Shadravan, H Naji, V Bardsiri,	[192]
190.	2019	Heterogeneous pigeon-inspired optimization	HPIO	Hao WangZhuxi ZhangZhen DaiJun ChenXi Zhu	[193]
191.	2019	Harris hawks optimization	HHO	Heidari, Ali Asghar; Mirjalili, Seyedali; Faris, Hossam; Aljarah, Ibrahim; Mafarja, Majdi; Chen, Huiling	[196]
192.	2019	Emperor Penguins Colony	EPC	Harifi, Sasan; Khalilian, Madjid; Mohammadzadeh, Javad; Ebrahimnejad, Sadoullah	[198]

6. Summary

In the real life the daily problems are becoming more and more complex in a way that it become very difficult for a traditional methods to solve them within a reasonable time.

Metaheuristics algorithm have been used to solve the real-life problems in an optimal time and effort. In the past many algorithm have been developed that belongs to metaheuristic algorithms.
This paper is an attempt to provide a historical list of some of metaheuristic algorithms that have been used between 1961 and 2019, it provides the year of establishments, authors name, abbreviations and the reference of the algorithm.

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