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A systematic review of meta-heuristic algorithms in IoT based application

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ABSTRACT

Internet-of-Things (IoT) has gained quick popularity with the evolution of technologies such as big data analytics, block-chain, artificial intelligence, machine learning, and deep learning. IoT based systems provides smart and automatic framework for the efficient decision making and automation of various task to make human life easy. Meta-heuristic algorithms are self-organized and decentralized algorithms used for solving complex problems using team intelligence. Recently, meta-heuristic algorithms has been widely used for solving a number of IoT based challenges. This paper presents a systematic review of meta-heuristic algorithms used for unfolding the IoT based applications. The broad classification of existing meta-heuristic based algorithms has been documented. Further, the prominent applications of IoT based system using the meta-heuristic algorithms are presented. Moreover, the current research questions are included to illustrate the new opportunities for the researchers. Finally, the current trends in IoT and possible future directions are documented. This paper will provide new directions to the researchers working in the field of meta-heuristic algorithms and IoT based system.

1. Introduction

Meta-heuristics are one of the prominent approach for solving a number of complex real-world problems. These algorithms are truly inspired by the fascinating behaviors observed in nature. Over the past few years, the growing complexity in the optimization based problems has motivated researchers to explore efficient problem-solving algorithms which focuses on decentralized, and self-organized systems [1,2]. Meta-heuristics are inspired by the behavior of physical phenomenon, biological evolution, and living beings, such as fish, birds, ants, termites, and birds. These are characterized by interactions between local individuals and provide intelligent behaviors at various group levels [3]. Different meta-heuristics have been introduced and applied successfully to solve a wide range of applications. Moreover, the new algorithms which have been offered are still under study, and need to prove their efficiency. A number of reviews have been proposed for the various applications of meta-heuristic algorithms. Unlike, the existing work present in the literature, this paper gathers the scope of application and provides the suitable findings for the IoT based applications. The present work helps the researchers to localize their research in the conclusive direction. Moreover, the key findings in the literature might be used by the researchers to work on a variety of meta-heuristics for solving IoT based applications. In recent year, internet-of-things has been widely studied and applied in distinct fields like the medical, traffic monitoring systems, smart cities, and wearable devices [4]. Internet-of-Things (IoT) is an umbrella of other technologies comprised of sensors, actuation, and data processing for the application and service development. The prime aim of IoT is to provide small objects with intelligence to decide, perceive, and cooperate with other machines, objects, and even humans. It is an area of research where physical entities like machines and humans are connected through a network. The information is shared quickly, enabling a novel category of service and applications. As the IoT network expands, this increases velocity, variety, and a large volume of data. There are several challenging issues in IoT systems as their dynamic properties, mobility of devices, and communications in wireless mode. However, the flexibility and robustness properties in meta-heuristics make a successful design paradigm to deal with IoT based complex problems. Therefore, meta-heuristics algorithms act as a source of inspiration for complex systems of IoT, which are applied in real-time actions and can be modeled with IoT based approach to achieve some goals. Fig. 1 depicts the integration of meta-heuristics and IoT for solving the real time problems. In this way, a global optimum is reached from the simple rules for individual behavior and communication among the individuals. In such type of varying environmental conditions, a self-organizing ability needs to be adapted to scale efficiently. Recent literature reports a number of nature inspired algorithms established in the major application areas. This paper embodies a systematic literature review which reveals the major meta-heuristics algorithms in internet-of-things based systems

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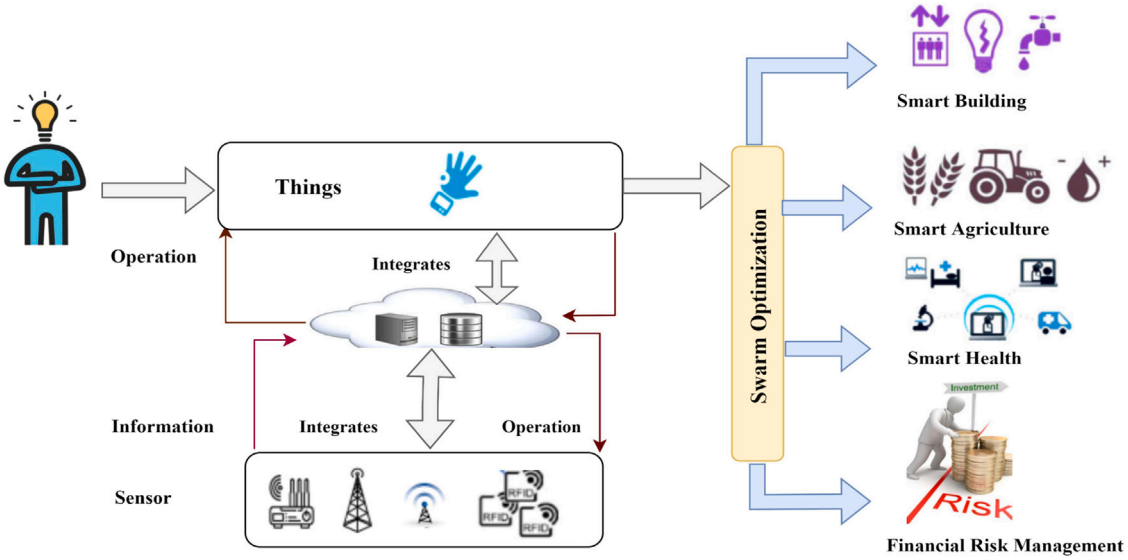

Fig. 1. Integration of SI algorithms in IoT systems.

employed till date [5]. The objective of the current study is in three folds. First, a comprehensive overview of algorithms and their usage in various applications have been provided. In the next phase, different applications of meta-heuristics in IoT based systems is illustrated. Finally, important features of meta-heuristics in IoT, recent trends, challenges, research questions, and improvements to be addressed in future work are mentioned.

2. Related work

This section reveals the broad classification of meta-heuristic algorithms present in the literature. The algorithms are classified in five categories based on their nature. Also, the IoT based applications of different meta-heuristic based algorithms is presented.

2.1. Meta-heuristic algorithms

Concurrently with the new era of information technology, a large number of optimization problems are emerging in different fields such as bio-informatics, computer vision, big data analytic, and Internet-of-Things etc [6]. Unfortunately, majority of the real world optimization problems are NP hard in nature which cannot be decoded in a polynomial time domain. Therefore, only small scale instance can be handled using exact mathematical methods. Rather than giving up, the investigators thought to use possible approximation methods which can find some feasible solution in the given time. These algorithms can be categorized to meta-heuristics and heuristics based on the randomization approach. The substantial difference between both algorithms is that heuristics algorithms are more problem-dependent in comparison to meta-heuristics. These algorithms are restricted to some specific problems. In contrary, meta-heuristic algorithms can be applied to atmost all optimization problems, as they uses the optimizer knows as black box. The Recent literature reports a number of existing nature inspired meta-heuristics algorithms namely, evolutionary Algorithms, bio-inspired algorithms, swarm intelligence, and physical based algorithms. This study performs a systematic literature review on technological advancements in field of swarm intelligence in IoT. The literature was collected from eight popular databases namely, google scholar, ACM digital library, elsevier, frontier media, IEEE explorer, science direct, hindawi publishing corporation, and taylor francis. The most relevant reviews, cited papers, and current hot spots are investigated. The information presented in Fig. 2 shows the summarized survey report of several paper.

2.2. Classification and applications of meta-heuristic algorithms

In the last four decades, more than hundreds of meta-heuristics algorithms have been developed for solving several real world optimization problems over a variety of domains. In this section, a classification and summarizing of existing meta-heuristic algorithms has been illustrated. Moreover, the classification of the meta-heuristics based on different applications has been also documented in Table 1. Fig. 3 presents the classification of the existing meta-heuristics based on their natural behavior.

2.2.1. Evolutionary based meta-heuristics algorithms

Evolution-based methods are inspired by the principles of Charles Darwin, theory of natural selection, which is based on survival of the fittest in a given environment [7]. Initially, these algorithms starts with a set of population and consequently search process takes place over successive generations till the most feasible solution is obtained [8]. For evolutionary computations, a number of algorithms has been introduced such as bio-geography based optimizer [9], genetic programming [10], evolution strategy [11], granular agent evolutionary algorithm [12] and virulence optimization algorithm [13]. Besides, to solve the conventional optimization issues, evolutionary based methods can be employed in providing the solutions to robotic motion planning, knapsack problem, travelling salesman problem, fuzzy logic based solutions, and in training the artificial neural networks. These algorithms are widely applied to resolve the different real world challenges of engineering, agriculture field, fundamental research, and in industries.

2.2.2. Physics based meta-heuristics algorithms

The physics based methods are inspired by physical rules present in the universe such as cooling and heating of materials, newtons law of gravity [14,15]. Simulated annealing based algorithms shows different behaviour at different temperature. During the physical process, first it warms the material and then gradually decrease the temperature for decreasing the defects, which reduces the energy of system. Simulated annealing gives better performance in finding the optimal solution. Further, their is no starting point strategy in such algorithms. Some of the popular algorithms in simulated annealing are ray optimization, black hole algorithm [16], gravitational local search algorithm [17], find fix finish exploit analyze [18], electron search algorithm [19], harmony search [20] and shuffled frog leaping algorithm [21]. These algorithms has shown the promising results in dealing with the real world problems. Further, experimentation has been performed to check

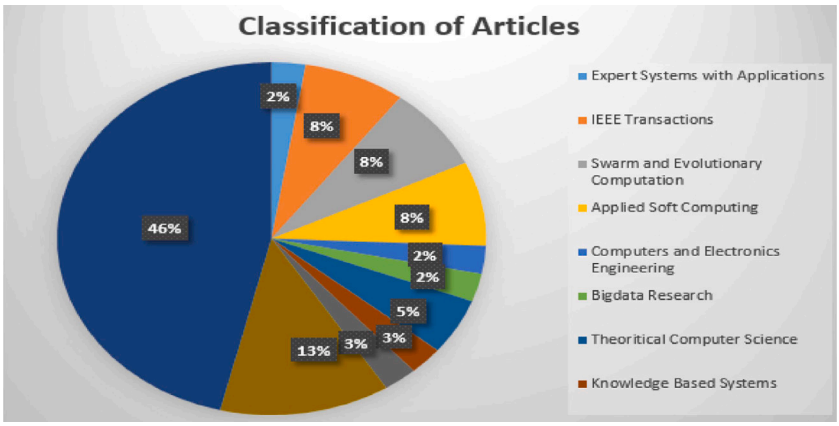

Fig. 2. Distribution of papers in different database.

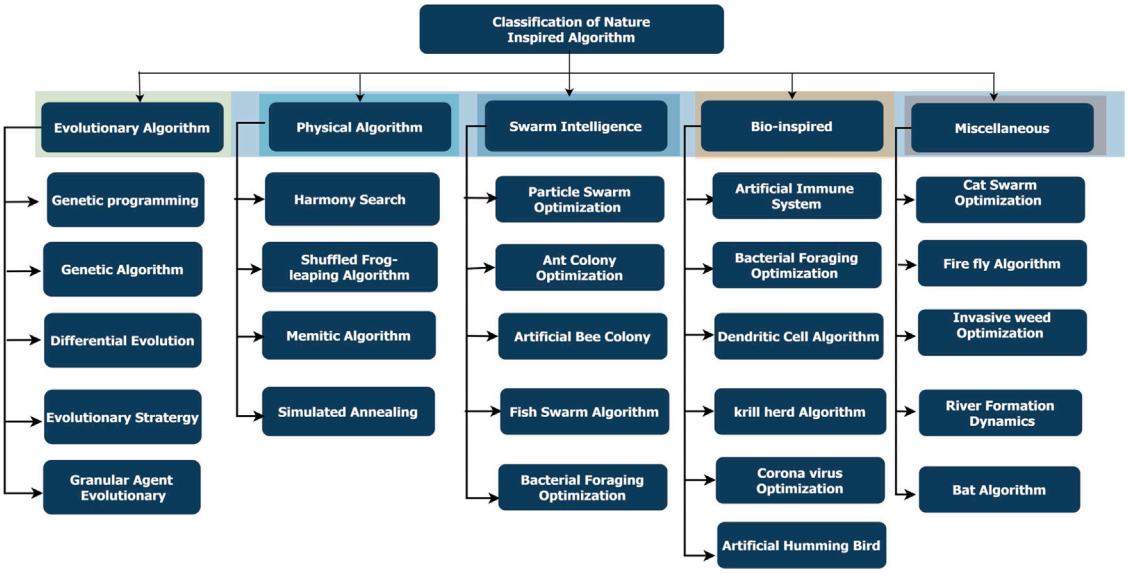

Fig. 3. Taxonomy of Meta-heuristics Algorithms.

the possibility of integration of fundamental physics based behaviour in recent applications such as in structural aligning, retrieving information from web, time frequency analysis, routing problems of vehicles, and in testing of softwares. However, these applications sometimes cannot fully utilize the advantages proffer by distributed physics architectures.

2.2.3. *Swarm intelligence based meta-heuristics algorithms*

According to Collins dictionary, swarm intelligence is an artificial intelligence approach of problem solving using the organized collective behavior of social animals or insects [22]. Moreover, the origin of swarm intelligence are embedded in the biological studies. Swarm intelligence is concerned with the intelligent multi-agent system which are inspired by the collective intelligence. Furthermore, this collective intelligence comes from the interaction of homogeneous agents. For this, no such global pattern is required to govern the interactions among the insects which are executed on information provided locally. Various algorithms have been developed on different intelligent behaviour. The biological swarm intelligence is found among the flocks of birds, colonies of ants, schools of fish, mosquito host seeking, social spider and honey bee mating. Some of the popular swarm intelligence algorithms are ant colony optimization [23], particle Swarm Optimization [24], artificial bee colony [25], fish swarm algorithm [26] ageist spider monkey optimization [27], lions algorithm, [28], whale optimization algorithm [29], spider monkey optimization [30], dragonfly optimization [31], bee swarm optimization [32], learning swarm optimization framework [33], photo voltaic swarm optimization [34], coronavirus optimization [35], mayfly optimization algorithm [36], horse herd optimization algorithm [37] and artificial humming bird algorithm [38]. These different applications has envisioned to resolve the several real world challenges.

2.2.4. *Bio inspired based meta-heuristics algorithms*

In the current scenario, bio-inspired algorithms is getting more prominence. The biologically inspired algorithms comprises the majority of meta-heuristics algorithms which are derived from behaviour of living organism biological evolution [8]. In particular, these algorithms are concerned with intelligence derived from nature algorithms that are distributed, decentralized and self organized malleable in nature. As the world is moving towards the digital era, the size of data is increasing exponentially. To extract the meaningful information from decentralized data is one of the challenge. Furthermore, to find the optimal solution is very tedious task. To overcome this some intelligent approaches are required. Some of the intelligent bio inspired algorithms are artificial immune system [39], where we stand & what is the next [40], salp swarm optimization [41], a long road ahead [42], pity beetle bio-inspired [43], bacterial foraging optimization [44], dendritic cell algorithm [45], and krill herd algorithm [46]. Different researchers has showcased the use of bio inspired algorithms in different applications such as in text summarization, wireless sensor networks, NP hard

Table 1
Classification of algorithms based on applications.

Category	Algorithm	Inspired	Application areas	Year
Physics based [14]	Simulated Annealing (SA)	Inspired by behavior of systems with many degree of freedom in thermal equilibrium	In multivariate or combinatorial optimization	1983
Physics based [59]	Memetic Algorithm (MA)	Inspired by population based hybrid genetic algorithms	Optimization problem for chemical process	1989
Evolutionary based [7]	Genetic algorithms (GA)	Inspired by the process of natural selection that belongs to the larger class of evolutionary algorithm	For solving high quality solution to optimization and search problems	1992
Physics based [20]	Harmony Search (HS)	Mimicking the improvisation of music players	Travelling salesman problem, A specific academic optimization problem, A least cost pipe network design problem	2001
Bio inspired [44]	Bacterial foraging optimization (BFO)	Foraging behavior of Escherichia coli bacteria	Machine learning, Pattern recognition, Mathematical analysis, Neural network problems	2002
Bird [24]	Particle swarm optimization (PSO)	Movement of fish schools, and bird flocks	Data clustering, Data mining, Time series prediction, flow shop scheduling problem	2004
Insect-based [23]	Ant Colony Optimization (ACO)	Pheromone behavior of ants	Heart disease prediction, set problem, Clustering and classification problems, Image processing, travelling salesman problem	2005
Physics based [21]	Shuffled frog -leaping algo (SFL)	Population based cooperative search metaphor, inspired by natural memetics	For Solving combinatorial optimization problem	2006
Evolutionary based [10]	"Evolutionary Strategy (ES)"	"Inspired from self adaptive mutation rates"	Used to solve the problems related to vector of real numbers	2006
Bio inspired [45]	Dendritic Cell algorithm	Inspired from the function of dendritic cell of human immune system	Robotic classifier, dendritic cell population tuning	2007
Evolutionary based [60]	Differential Evolution (DE)	Inspired from Vector Difference property	Used to solve numerical optimization problem	2008

problems, diode solar cell models, and in optimization of networks. The aforementioned algorithms experimentally and theoretically, redefine the different parameters which are used for updating and evaluating the different applications.

2.2.5. Miscellaneous nature inspired meta-heuristics algorithms

In the last three decades, a number of nature inspired meta-heuristics have been applied to different real world applications. These algorithms are materialized as the prominent tools which provides an alternative solution to many traditional real time based applications. In the recent years, researchers have developed a number of meta-heuristics algorithms with intensification and diversification in search space. Several other nature inspired algorithms are river formation dynamics [47], chemical reaction inspired [48], brain storm optimization [49], adolescent identity optimization [50], cuckoo search algorithm [51], cat swarm optimization [52], squirrel optimization search algorithm [53], a novel hybrid optimizer for feature selection [54], invasive weed optimization [55], queuing search optimization techniques [56], firefly algorithm [57] bat algorithms [58], and gravitational search algorithm [17]. Further, from the above analysis and discussions of several algorithms proposed by the authors, it is quite crystal clear that competency's of these algorithms seems to influence different real world applications. The fundamental steps in developing these algorithms are observations, designing, mathematical module conversion, pseudo code development, and finally testing is performed. The applications areas of these algorithms has been applied in solving the pattern recognition, network routing applications, clustering of images, and decision making.

Table 2 presents the classification of different algorithms applied over last four decade including the application areas and from where these algorithms has been evolved. In addition, these studies did not prioritize the investigation of a specific optimization techniques. Instead, a broad spectrum of them is exploited.

3. Meta-heuristic based IoT application: an overview

In this section, an extensive review of the meta-heuristic algorithm in IoT based systems has been presented. The applications are categorized in four major areas.

3.1. Meta-heuristic based IoT for enhancing health care services

In recent years, swarm intelligence (SI) in IoT emerged as the burning research area which provides solution to complex real world application like health care service [64]. SI in IoT plays an important role in monitoring the healthcare sector in smart cities due to its ability to retrieve the data of different patients, data collection using sensors, disease diagnosis and other health services in less amount of time and cost. However, to process the request of each stakeholder is the biggest challenge in smart cities [65]. Furthermore, to enhance the performance and to reduce the execution time of requested tasks different task scheduling algorithms are used. The above techniques will help the different stakeholders to minimize the time turnaround time and maximize the resources. In addition, to improve the task scheduling problem and providing magnified support the stakeholder, intelligent optimization techniques has been introduced like particle swarm optimization and parallel particle swarm optimization. Although the different algorithms and frameworks has been proposed to improve the performance of existing healthcare system. However, there are certain limitations namely the first one is the problem of the data set. For the better performance of models, large scale data is required. Secondly, selection of optimal approach in different situation in this sector effects the performance of the model. Besides this, there are some issues which are unresolved and possible trends for the future work such as information fusion, data analytics system, knowledge interpretation, privacy and security.

3.2. Meta-heuristic based IoT in financial risk management

In recent years, with growing use of internet of things, different Swarm intelligence based IoT applications have been developed in a

Table 2
Classification of algorithms based on applications.

Insect -based [25]	Artificial Bee Colony (ABC)	Foraging behavior of honey bee	Medical pattern classification, Image watermarking optimization, vehicle routing, route optimization	2009
Amphibious-based [25]	Fish swarm algorithm (FSA)	Natural collective movement of fish, and their social behavior	Robot control optimization, Routing problem, Artificial neural network training	2009
Wild-based [61]	Grey wolf optimizer (GWO)	Predatory behaviors of social hierarchy, of wolf colony	Satellite image segmentation, Clustering, Solving multiobjective problem, optimizing artificial neural networks	2011
Evolutionary based [62]	Differential Evolution (DE)	Inspired from onlooker bee phase	Used to solve Model Order Reduction problem for Single Input, Single Output Systems.	2012
Bio inspired [39]	Artificial Immune system (AIS)	Inspired from human immune system	Used for damaged detection in structural health monitoring	2012
"Evolutionary based [9]"	"Genetic Programming (GE)"	From the natural genetic to the population of programs	Heuristic search techniques, hill Climbing, multi expression Progh	2017
Insect-based [63]	Beer froth artificial bee colony (ABC)	Foraging behavior of honey bee	Job shop scheduling, flow shop scheduling, batch scheduling",	2018
Bio inspired [30]	Spider monkey optimization	From the behaviour of monkey	This algorithm is developed to enhance the exploitation and exploration of smo algorithm	2019
Bio inspired [35]	Coronavirus optimization	From the behavior of novel covid-19	This algorithm is mainly defined to identify, how it may affects the health of people	2020
Bio inspired [37]	Horse herd optimization algorithm	From the behaviour of horses' herding for high-dimensional	Intimates the behaviour of horses at different ages	2021
Bio inspired [38]	Artificial humming bird algorithm	From the behavior of specific flight skills of humming birds	Defines the intelligent foraging techniques	2022

broad field of financial risk management. As the financial data is growing at the massive rate, the data is collected in unstructured form [66]. As data is collected from multiple sources like mobile networks and internet, proper prevention and management of multiple risk is an important concern for commercial banks. Therefore, there is need to develop some risk prediction models which are intelligent enough to predict the behaviour with better accuracy. In case of financial risk management the credit risk assessment is one of the major core consent to the investors [67]. Furthermore with the development of internet-of-things and artificial neural network theory, majority of the researchers have developed some nonlinear models for evaluating the credit risk of different bank loans [68]. Therefore, using these models testing of multiple financial data is collected from different companies for the prediction of bankruptcy. Different algorithms has been applied in the field of financial risk management such as particle swarm optimization based back propagation neural network used in banks for internet of things deployment. This literature sheds light on the recent emerging challenges associated with financial risk management such as feature selection, financial distress prediction, option pricing, and bankruptcy prediction which are gaining the attention of practitioners and scientist from several communities. Most of these challenges are complex in nature. However, recent optimization based algorithms tried to resolve these challenges up to certain extent.

3.3. Meta-heuristic based IoT in smart agriculture

Collaborative swarm intelligence based IoT constitutes promising solution for smart agriculture system. Unfortunately, smart agriculture has several constraints and complicated topology. The prime constraint is to find the optimized path route to work collaboratively [69]. As population size is increasing at a massive rate, the current agricultural techniques would not be enough to fulfill the food needs. In order to boost up the existing farming techniques, different measures needs to be taken for improving the productivity. The organic farming has shown promising results in the further improvement of agricultural productivity. To overcome the recent challenges of agricultural activities, researchers robotics and intelligent system has been introduced. Technological support in precision agriculture has come up with the revolution for the development of crop health on farms [70]. Furthermore, it require collection of data, interpreting and finally acting on data which has the capability to be automatized with swarm intelligence in IoT based systems. Different algorithms have been proposed for the proper path planning in agricultural fields namely Ant colony optimization, Bellman-held-karp, [71] K-means clustering, and Christofides based on nearest neighbour. Moreover, a number of agricultural robots has been introduced in this field. These includes the autonomous path planning and agricultural robots in rural areas to preform the different tasks such as plucking fruits, weeding, pesticides spraying, and cultivation. However, in the large farmland conditions, several other alternative solutions are required which can save time as well as money.

3.4. Meta-heuristic based IoT in infrastructural development

The impact of new technologies, especially in urban areas has shown tremendous affect in developing countries. Furthermore, rapid advancement of these technologies has overthrow the time and space that the people are now familiar today [72]. In recent years swarm intelligence based IoT systems have been introduced in the infrastructural development like smart cities. However, ensuring reliability, security, efficiency, and scalability in smart cities is a challenging task. In these conditions swarm intelligence is a promising techniques which focuses on self organised and collective behaviour of decentralized systems. Smart infrastructures can be modelled by using latest software, digital communication networks, sensors and embedded intelligence. The modern infrastructures are developed, taking care of natural hazards, tornadoes, earthquakes, and floods which causes the severe damages and may lead to destruction of electricity, bridges, and communication systems. To overcome these challenges different algorithms have been proposed for the proper infrastructural development like a parallel military-dog-based algorithm [73] and enhanced grey wolf optimizer algorithm [74]. Further, these algorithms are used to early access the damage and provide the rapid solutions to avoid the substantial damages.

4. Research questions, challenges, and future directions

The motivation behind this review is to document the current research hotspots, trends, challenges, and future research directions. To answer this, investigation from the literature has been recorded and research question has been derived. Some of these questions are:

1. Research questions investigated

   - RQ-1: What are the fundamental concepts of meta-heuristics ?
     Reasoning: With the current growth of technologies, meta-heuristics techniques has been witnessed as the crucial asset. Optimization is everywhere, from economic to engineering design, for planning holiday to internet routing. As time, money, and resources are limited, the absolute utility of these resources are important. As real world optimization problems are non linear, to select an optimal model in not an easier task. Therefore, meta-heuristic helps in solving these computationally complex problems.
   - RQ-2: What is the contribution of current research in meta-heuristics in IoT ?
     Reasoning: Swarm intelligence has been involved with IoT based system. As IoT based systems are complicated, it contains smart objects, SI based decentralized algorithms are preferred to resolve these issues. Therefore, several intelligent SI algorithms can be used to solve these critical issues of IOT based systems because of its device mobility, information provision, dynamic properties, and wireless communication. SI based algorithms such as artificial bee colony, ant colony optimization, and social spider optimization has been applied to solve several real world problems in normalizing IoT process.
   - RQ-3: What technologies are used to develop a design pattern for meta-heuristics algorithms ?
     Reasoning: Analyze the frameworks and technologies adopted from different domains for designing meta heuristics algorithms. Design pattern conquer the crucial factors of adopting the key practices in an abstract form. Different computer scientists and researchers has used pattern based perspectives which includes methodological, structural, behavioral, and component-based patterns for designing the optimization algorithms.
   - RQ-4: What are different analytical techniques used for validating the performance of meta-heuristics algorithms ?
     Reasoning: Compare the applicability of validation techniques used, according to type of data collected. Different evaluation metrics has been used for validating the performance of meta-heuristics algorithms such as precision, recall, F 1 score, specificity, and unimodel and multimodel benchmark functions.
   - RQ-5: Where the research articles have been published ?
     Reasoning: Discover and understand the potential of different algorithms of meta-heuristics in solving the various problems. For this different publication in journals, conference, books, proceedings are taken into account. To reveal the research venue where the research articles has published the research results are shown in figure two.

2. Research challenges and future directions

Over the years, leveraging meta-heuristic algorithms to sustain real-time applications in IoT environments is inevitable. Although the aforementioned meta heuristic techniques are efficient, still numerous challenges and future directions must be addressed before scaling to the next level. Following research challenges and future directions are mined from the literature.

- Software & hardware IoT challenges in meta heuristic techniques: From the last two decades, internet of things has gained a significant attention with the use of smart devices in the different fields. Recently, meta-heuristic optimization techniques is required to make several system such as agriculture, health, infrastructure, financial risk management and its allied sectors smart. However, real time implementation of meta-heuristic with IoT based framework has two significant challenges. Firstly, the lack of professional sensors is the major hurdle to develop smart specially in agriculture sector. Secondly, the lack of networking communication, specially in rural areas affecting the entire system with the unreliable data transfer. Therefore, it is necessary to develop a feasible system for examining the performance of computationally complex problems in different situations.
- Functional & interoperability challenges: In the recent times, there is no single organisational structure developed which can handle the dynamic and high dimensional data. Furthermore, during the data transfer several security challenges such as data tampering, wiretapping, and replay attacks may be attempted causing security threat. For getting the best results several factors such as authenticity, data integrity, and confidentiality must be ensured during data acquisition and data transfer. However, some optimization techniques has been developed which can handle some problem up to certain extent. Capital investment in different applications mentioned in the literature may hinder the growth of this industry.
- Handling the large dimensional data: As the large amount of data is generated from several IoT devices. Further, the "curse of dimensionality" occurs when the dimensions of size of data increases. Therefore, there is need of smart infrastructure to process, analyze, and store data for the automation of various tasks. However, during the non-stationary environment i.e when the data is not static, some additional measures are required. These essential measures will help the meta-heuristic techniques to solve some satisfactorily dynamic problems. Moreover, platform as service models are gaining swift popularity due to low cost infrastructure such as sales force IOT platforms, thingWorx, and amazon web services.

5. Conclusion

With the advancement of new technology, Internet-of-things has evolved rapidly in various technologies such as in big data analytics, block-chain, artificial intelligence, and machine learning. Furthermore, these technologies can be applied in several diversified fields such as agriculture, healthcare, financial risk management and infrastructural development. This paper aims to introduce a high level of intelligence in IoT-based systems by investigating the potential of realizing meta-heuristic algorithms in IoT-based systems. The study shows that how meta-heuristics algorithms behave closely with new emerging ideas and applications. Moreover, it is very much clear that meta-heuristic algorithms are one of the efficient paradigms which are useful for presenting reliable and robust solutions to the systems based on IoT. This paper is presented in three folds. First, review and scope of different IoT base applications of meta-heuristic algorithms have been discussed. In the second fold, some existing IoT systems with meta-heuristic based algorithms have been documented. Furthermore, from the investigated studies some description of research questions has been included. Finally, this paper reviews and summarize the major requirements of IoT-based systems. In future, some other swarm based applications such as block-chain and big data may be covered.

CRediT authorship contribution statement

Vivek Sharma: Written manuscript hand performed drafting. **Ashish Kumar Tripathi:** Collected data, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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