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**Research Article**

# Efficient Evolutionary Optimization Approach for IoT Based CNN Model

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**ABSTRACT**

IoT is network that connects various physical devices and enables their remote control. In this configuration, automobiles, buildings, and various other objects are outfitted with computer hardware and software as well as sensors and a network. As a result of this, these objects can now collaborate and exchange data with one another. The purpose of CNN model is to establish whether or not computers can be taught to enhance their ability to make accurate predictions. CNN model plays an essential role in the day-to-day operations of most successful companies in the world today, like Facebook, Google, and Uber, to name just a few. The use of CNN to gain a competitive advantage is becoming increasingly common in today's business world. The idea that different species can adapt to different environments over the course of their history is the fundamental idea behind evolutionary algorithms. In order to solve a problem, evolutionary algorithms consider a number of different options and then select the one that is most effective.

**Keywords**: IoT, CNN, Evolutionary, Optimization

## 1. INTRODUCTION

IoT allows remote control of physical devices. In this setup, vehicles, buildings, and other items are given a dose of hardware, software, sensors, and a network. Because of this, these objects can now share and gather data. CNN model is to determine whether or not computers can be trained to improve their predictive abilities. CNN model is an integral part of the day-to-day operations at several of today's most prominent corporations, like Facebook, Google, and Uber. CNN model is now being used by many companies as a competitive advantage. Evolutionary algorithms are based on the premise that species can change their habitats over time. Evolutionary algorithms take several potential solutions to a problem and pick the best one [1-2].

## 1.1 Internet of Things

IOT is a remote-controlled network of devices. This system integrates hardware, software, sensors, and a network into vehicles, buildings, and other products. Data may be collected and shared among devices. IoT allows things to be recognised and controlled remotely using existing network infrastructure, simplifying integration of the real world with computer-based processes and increasing efficiency, accuracy, and profit. In figure 1, important IOT components are specified [3].

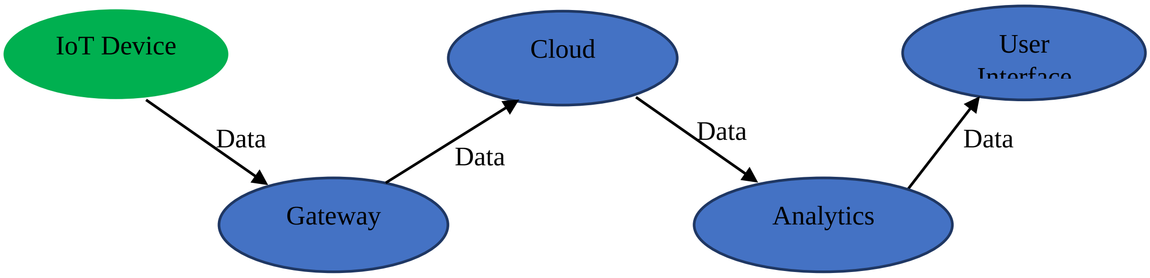


**Fig 1 IoT Components**

It is creating a new IT world. The server room, desktops, and handhelds process data quickly. It is fast approaching from all sides, and the world is feeling its presence. Most of our everyday items are linked or will be. Smart software lets them identify and exchange crucial data. Databases, media platforms, and applications are becoming increasingly integral to our lives. They'll eventually cover our lives like thin, developed skin. Our computerised future might be "No Net, No Planet." This year, 8.4 billion IoT gadgets will be in circulation. They are growing quickly since their annual growth rate is close to 31%. By 2020, the global IoT industry might be worth $7.1 trillion. IOT devices need layers like those in Figure 2. Computers have three abstraction layers [4].

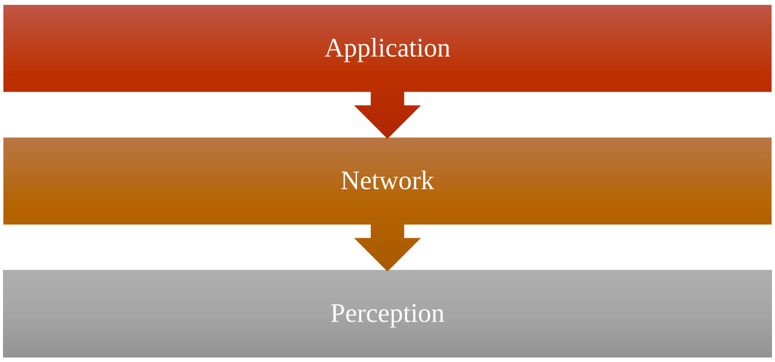


**Fig 2 IoT Layers**

Unlike typical data processing, IoT data and information are unique. IoT information is little and distributed. It turns out the IoT has many devices and nodes. The setup will include these. IoT has numerous names. The notion of a "associated object" is perhaps as old as the Internet or correspondences. Perhaps the first related items were personal computers. Despite their differences, they will always be considered independent goods since they demand user interaction. Early IoT applications, known as telemetry or telemetric today, interfaced modern equipment, infrastructure, and even corporate armies. The buyer community has many unique ideas. It also covers a similar ice chest. The phrase "machine-to-machine," or M2M, has become prevalent, with a focus on networks. In recent years, "Web of Things," or "IoT," has become commonplace. This word appears in publications, online journals, organisation purpose statements, and China's top leader's speeches. Internet of Everything, IoIT, and others are only a few variations. IoT is distinguished by AI, connection, sensors, active engagement, and small devices. We'll briefly review each trait:

- **AI:** Through data collection, AI algorithms, and networks, IoT transforms objects into "smart" ones, enhancing many aspects of human life. Simply placing sensors in fridges and cabinets to alert your favourite grocery shop when veggies are low may do this.
- **Connectivity:** New networking and IoT technologies have made it unnecessary to subscribe to a single supplier for connectivity. Networks may operate with less resources and lower sizes.
- **Sensors:** Without sensors, IoT is useless. Their definitions transform the IoT from a network of devices to a viable interactive system.
- **Active Engagement:** Nowadays, passive use of internet-connected gadgets is common. IoT revolutionises interactive media consumption, creation, and delivery.
- **Small Devices:** Smaller, more powerful, and affordable electronics have emerged. IoT uses small, functional devices to achieve accuracy, scalability, and flexibility [5-8].

IoT development requires using existing protocols and network infrastructure. Radio frequency identification, near field communication, low power wireless, low power radio protocols, Wi-Fi Direct, LTE-Advanced, and low power Bluetooth are key IoT enablers. These advances may provide IoT devices the networking capabilities they require rather than the general network infrastructure. Fig. 3 shows IoT advantages, which will be explored below:

**Benefits of IoT**

- **Security**
- **Reliability**
- **Personalization**
- **Collaboration**
- **Interoperability**
- **Identity Management**
- **Interoperability**
- **Privacy**

**Fig 3 Benefits of IoT**

- Protection: Financial management companies need a convention for managing uncommon events and preventive measures to address potential risks. Data handling and maintenance must be restored. Keeping IoT data secure while safeguarding customers and following rules is the objective.
- Safety: Ensure secure information collection, transmission, and follow-up. Since most technology is new and somewhat field-tested, users face several potential vulnerabilities in their actions and consequences.
- Identity management: Managing the expanding number of linked home gadgets and their intricate interactions with owners.
- Interoperability: Companies advance interoperability by creating new means for transmitting and coordinating devices across fixed, mobile, and computer systems. Not compromising compatibility will fail the IoT experience.
- Joint effort: IoT devices should share internal settings with one other and consumers to maximise potential. Once compatibility issues are resolved, these devices will be fully functioning value-added devices that can effectively transfer data.

- Personalization: These devices may significantly alter the medical services business, focussing on prevention and treatment.
- Unwavering quality: Maintaining quality requires fixing flaws when devices break. For automobile accidents, water shortages, fires, and health inspections, plan actions and backups [9–17].

### 1.2 CNN Model

Images or time-series data having a grid-like pattern are ideal for CNNs. CNNs use their architecture to derive hierarchical properties from convolutionary layers. Filtering these factors selects temporal and geographical relationships. This method preserves crucial data while simplifying calculation. They can recreate elaborate patterns better because to entirely linked layers, activation mechanisms, and pooling layers. Due to its effectiveness in handling large, high-dimensional data, CNNs are essential in computer vision, natural language processing, and IoT systems. Their capacity to analyse real-time data from several sources in IoT-based distributed systems enables anomaly detection, predictive maintenance, and secure communication. CNNs' adaptability makes them essential for intelligent system growth [18-20].

#### 1.2.1 Classification of CNN

CNNs have versatile designs for many applications. Structure, use case specialisation, and simplicity enable CNN classification generalisations. Figure 4 shows how each kind optimises performance for certain usage and addresses distinct issues.

1. **Vanilla CNN:** This simple CNN architecture consists of sequential convolutional, pooling, and totally connected layers. Considered basic tasks, common uses of vanilla CNNs include photo categorisation and object recognition.
2. **Deep CNN:** More convolutional layers enable extraction of abstract and higher-level characteristics. Models like VGGNet excel in picture identification and video analysis.
3. **Recurrent CNN:** Recurrent CNNs magnify the power of CNNs and RNNs. On sequential data tasks like time-series analysis and speech recognition, they do quite well by combining geographical and temporal information.
4. **FCNs:** FCNs replace fully connected layers with convolutional ones to provide pixel-wise predictions. They are used extensively when one knows the local and global contexts.
5. **Inception CNNs:** Similar to GoogleNet, with parallel convolutional routes and varied filter sizes. This lets them acquire data at several sizes and efficiently handle complicated datasets with different patterns and resolutions.
6. **ResNet:** ResNet tackle the vanishing gradient issue in deep architectures by shortcut connections utilising residual CNNs. ResNet models are notable for their efficiency and accuracy in deep learning applications.
7. **Generative CNNs:** Generative CNNs, used in GANs, excel in image synthesis, style transfer, and super-resolution tasks. As they learn and generate fresh data, these models may replicate training data well.
8. **Hybrid CNNs:** Hybrid CNNs integrate ML architectures such as LSTM networks or SVMs. In IoT and other niche applications, these models excel in spatial and temporal analysis of diverse data.
9. **Graph CNNs:** Designed to address data shown in graph structures rather than grid forms, graph CNNs Among the applications are those in molecular structure modeling, traffic prediction, and social network analysis.

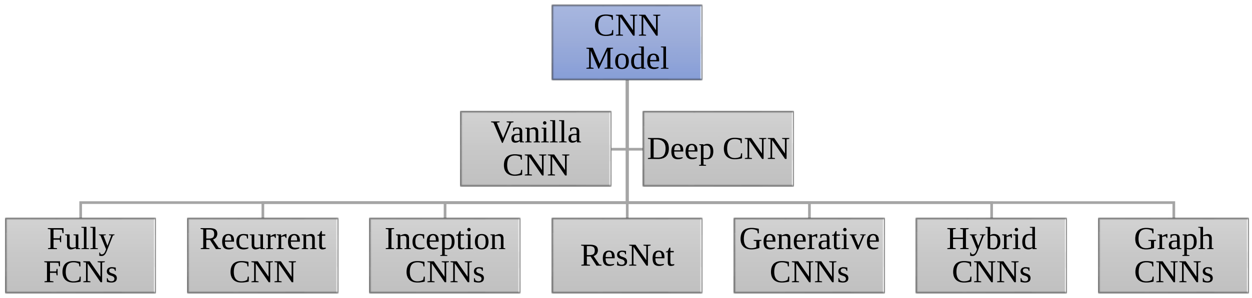


**Fig 4 Types of CNN**

The ability of the CNN models to be categorised reveals their degree of fit to certain uses. This is especially true in heterogeneous distributed systems depending on IoT, where practitioners may gain from understanding the benefits and limitations of each sort of architecture in order to pick the optimal one for their intended application.

### 1.2.2 Applications of CNN

Particularly in fields with large, high-dimensional datasets, CNNs have revolutionised numerous fields by providing fresh solutions to challenging problems. Their ability to automatically and adaptatively learn feature hierarchies from incoming data has made them increasingly important in many different fields. Here is a summary of some quite significant CNN uses:

1. **Image Classification:** CNNs are heavily used in classification problems involving images, including medical image diagnosis or object recognition in photographs.
2. **Object Detection and Localization:** CNNs are required to recognise and point out things in static pictures or moving video. Among the uses are security surveillance, traffic monitoring, and augmented reality systems.
3. **Medical Image Analysis:** CNNs are often used in the healthcare sector to process medical imaging including X-rays, MRIs, and CT scans.
4. **NLP:** NLP searches text for repeating patterns using CNNs. CNNs find uses in sentiment analysis, text categorisation, and machine translation when they effectively represent the links between words in a sequence.
5. **IoT and Smart Systems:** CNNs sort data streams from connected devices in heterogeneous distributed systems based on the IoT for tasks like anomaly detection, predictive maintenance, and secure communication.
6. **Autonomous Vehicles:** CNNs are mostly responsible for the progress of autonomous cars. Their main goal is to recognise people, road signs, lane marks, and impediments via real-time analysis of data gathered by cameras and sensors.
7. **Fault Diagnosis in Machinery:** CNNs are used industrally in the diagnosis of machine defects by use of vibration signals and sensor data collecting.
8. **Content Generation:** CNNs are often used with GANs with the aim of creating convincing images, videos, and sounds.
9. **Video Analysis and Surveillance:** CNNs assess frame-by- frame data in many video analytics applications like crowd surveillance, activity detection, and behavioural analysis.
10. **Agricultural Technology:** CNNs are used in precision agriculture for purposes of plant disease identification, soil quality analysis, and crop monitoring by means of image-based data acquired by drones and IoT devices.
11. **Environmental Monitoring:** By sorting through satellite photos in search of signals of urbanisation, natural disasters, and deforestation, CNNs help in environmental monitoring.
12. **Retail and E-Commerce:** Consumers could utilise CNNs in visual search engines to search objects using photos.

CNNs' outstanding performance and flexibility help them to be valuable in both established and innovative fields.

### 1.3 Evolutionary Optimization

One of various optimisation names, metaheuristic optimisation uses meta-heuristic approaches to discover optimum solutions [51-56]. The phrases "meta" and "heuristic" signify "solution" here. Fixing difficulties may require achieving objectives. This optimum solution is valid for resilient objective functions. In repeated cycles, the metaheuristic algorithm explores all possible choices. Some algorithms search globally, while others search locally [57-62]. The objective function considers task-relevant measurements and features. Figure 5 shows the two primary categories: single-solution and population-based metaheuristics.

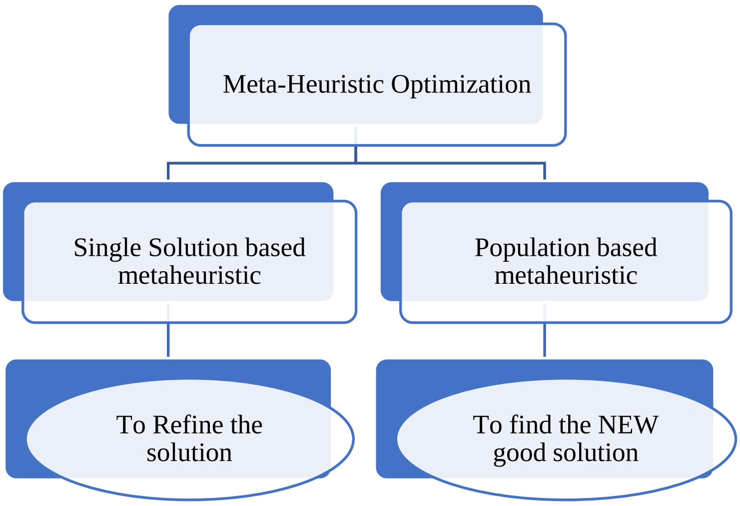


**Fig 5 Classification of Meta-heuristic Optimization**

Making money is the main goal, thus the best option is local. Because they are not built for optimum solutions, discovery-oriented techniques like population-based methods can only explore so far. Simulated annealing and tabu search seek the optimum choice. Figure 6 shows evolutionary algorithms and swarm intelligence as two of the most important population-based subcategories. Genetic algorithms and differential evolution are evolutionary algorithms. Swarm intelligence includes several algorithms.

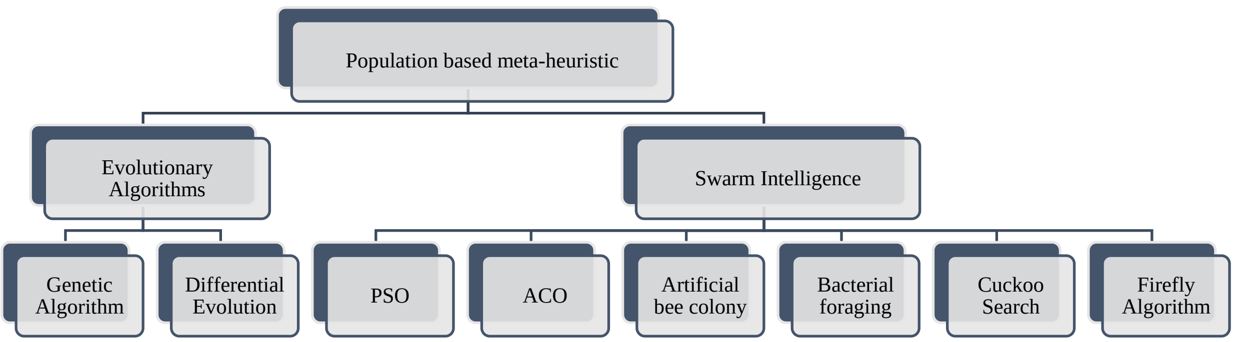


**Figure 6 Comprehensive look of various techniques of optimization**

Evolutionary algorithms presume creatures move. Evolutionary algorithms choose the best answer among many. Individual genetics are full with information. Mutation and hybridisation create new species from existing ones. DNA mutations alter DNA unexpectedly. Genetic crossover occurs when two individuals mingle genes. Health may be judged by fitness. Multiple methods mimic population evolution, including the Genetic Algorithm and Differential Evolution. On implementation, they differ. Genetic algorithms (GAs) mimic natural selection to pass on adaptive species. Simulating "survival of the fittest" across generations evolves problem solutions. Members of each generation are a search point and solution. People encode using letters, integers, floating point numbers, and bits. GAs use adaptive heuristic search and evolutionary algorithms. GAs utilises genetics and natural selection. These methods strategically discover good solution space sites using random searches and previous knowledge. They quickly and consistently deliver the greatest search and optimisation results. GA often starts with random chromosomes. A basic GA structure is shown in Figure 7. These chromosomes are hard. Based on concerns, chromosomal sites are recoded with numbers, letters, or binary digits. Gene locations shift randomly throughout development. Throughout evolution, chromosomes create populations. Evaluation functions determine chromosome validity. Assessments should include two key components. Genetic crosses mimic population fluctuations and breeding. Chromosome selection encourages stronger chromosomes for survival and reproduction. GAs may imitate practically any limitation using limited functions or specialised chromosome-coding.

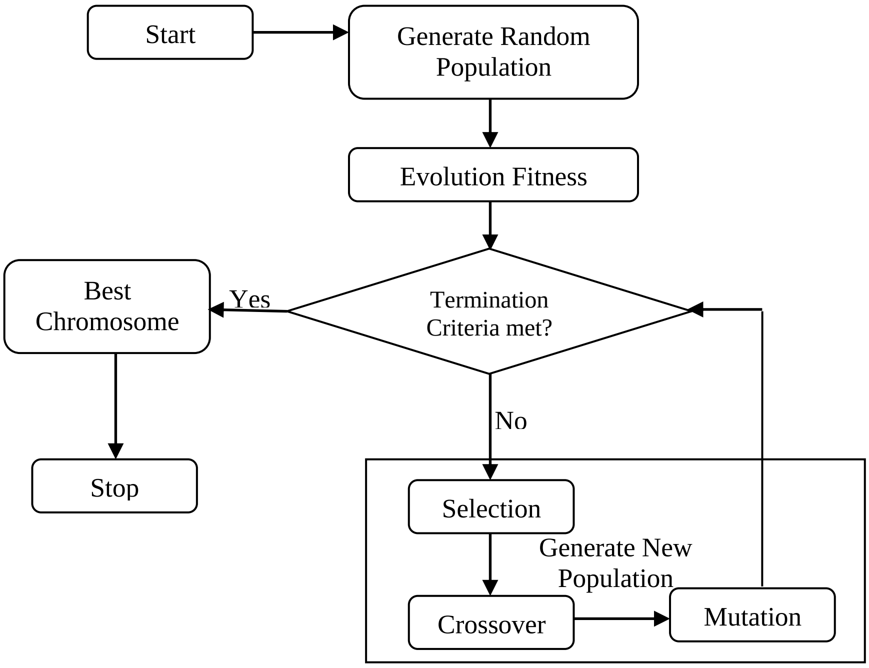


**Fig 7 Simple structure of Genetic Algorithm**

Differential evolution (DE) is a population-based metaheuristic search method that repeatedly improves candidate solutions to find the best solution. These algorithms quickly investigate large design regions without preconceived notions about the best answer. DE is popular for optimising multidimensional real-valued functions because it uses a population of individual solutions. This method works regardless of the optimisation problem's differentiability; it just requires a lack of gradient information. The program adds mutations into the population at each iteration to generate new solutions. Mutation creates a new vector by multiplying two population vectors by their weighted difference.

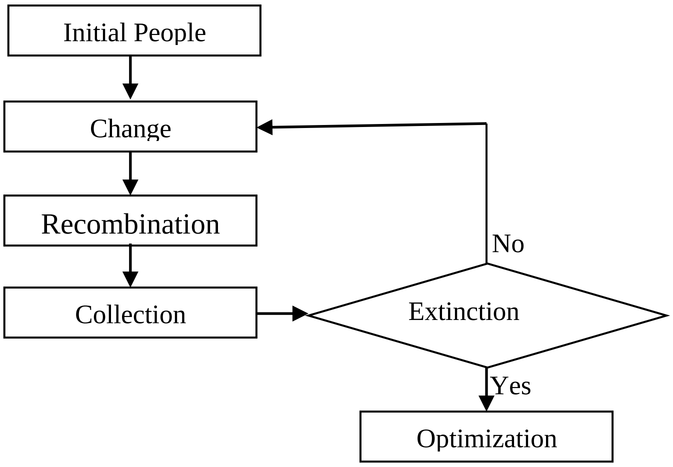


**Fig 8 Optimization with Differential Evolution**

Figure 8 shows how crossover combines the changed vector's features with those of a third, preset vector, the target vector, to accomplish this purpose.

To find the best design, the algorithm merges a population of possible solutions (individuals) to develop new solutions. Only candidates with the highest goal values are preserved for the next algorithm iteration, raising everyone's objective value while in the population.

## 2. RELATED WORK

This section discusses previously conducted IOT, CNN Model, and evolutionary optimisation research. With care, Rresearch was created. The publications that laid the groundwork for the study and guided it towards its goal are briefly examined.

W. Njima et al. (2019) examine IoT sensor indoor localisation using CNNs. A revised CNN model for high-dimensional sensor data helped the scientists locate construction locations. Even if it works, the research is not adaptable for dynamic IoT settings since it relies on sensor combinations [1].

Logeswaran K, et al. (2019) used ML to optimise a transactional database evolutionary pattern mining approach. A reinforcement learning-based technique for algorithm performance improvement automatically selects the appropriate fitness function for assessment during algorithm execution. During optimisation, the current optimal function was picked on the fly when numerous functions were competent [2].

Shams and Sagheer (2020) used natural evolution optimization-based deep learning to classify neurological illnesses. The proposed classifier combines numerous state-of-the-art techniques to categorise EEG data. Initially, the EEG data was wavelet-transformed into discrete frequency bands for spectral and statistical analysis. An artificial bee colony approach was utilised to choose beneficial traits from recovered ones. After applying the recommended NEDL classifier to the filtered features, the entire thing was evaluated on two epilepsy and motor imaging benchmark datasets [3].

A. Kaur et al. (2020) conducted RL-based evolutionary multi-objective optimisation on cognitive radio network spectrum allocation. Multi-objective optimisation is used to allocate spectrum in CR networks, taking into account network capacity and spectrum efficiency. NSGA-RL, an updated version of NSGA-II, self-tunes parameters to meet conflicting goals [4].

S. K. Sarma (2020) detects IoT cyberattacks using a Rider Optimisation Algorithm and Deep CNN. CNN architecture helps the model spot unusual network traffic patterns. The technique emphasises consistency and reliability, but its computational complexity decreases its efficiency, making real-time deployment challenging in IoT systems with limited resources [5].

W. N. Ismail et al. propose a CNN-based model for IoMT health variables in 2020. This method uses CNNs and health monitoring devices to predict health risks and provide real-time information. Even though it is great at detecting vital sign abnormalities, the model issues with data sources and scaling to IoMT systems [6].

J. R. Jian et al. (2020) tested and compared large-scale evolutionary optimisation. They tested multiple LSEO methods on a set of functions. They tested seven popular LSEO algorithms using CEC2010 and CEC2013. They then utilise simulation data to identify which algorithms performed better for benchmark functions. They finished with LSEO algorithm research directions [7].

Z. Deng et al. (2020) optimise CNN weight initialisation for IoT picture recognition. Consider RGB impact proportions to handle IoT sensor visual data more accurately and efficiently. The method's reliance on constant illumination and camera quality [8] restricts its IoT applications.

T. Ghosh et al. (2020) used ML and algorithms to optimise multi-response machining processes. The broad data-driven strategy may be tested with various production methods. The recommended approach was tested using various instances from the literature. The data-driven NSGA-III solution outperformed MOEA/D under boundary limitations. The insights might improve future machining quality and efficiency. They recommended the surrogate-assisted NSGA III and a multi-response manufacturing process optimisation technique [9].

S. Govindaraj and S. N. Deepa (2020) improve energy efficiency in IoT wireless sensor networks using CapsNet. The strategy prioritises data integrity and overhead communication reduction. The technique optimises energy usage but fails to scale to large IoT networks with numerous nodes [10].

W. Deng et al. (2021) described differentiated evolution for optimisation. To give a new neighbourhood approach, NBOLDE writers add additional evaluation criteria and weight elements to the neighbourhood model. They propose DE/neighbor-to-neighbor/1, a new neighbourhood mutation method that replaces enormous global mutation with efficient neighbourhood mutation using DE/current-to-best/1 [24].

K. C. Tan et al. (2021) discussed evolutionary transfer in computer science, a new optimisation frontier. Their study categorised ETO works by issue type. The paper also discussed many promising ETO research topics and some of the limitations in this growing academic field of computer intelligence [25].

M. Zakhrouf et al. (2021) achieved fresh streamflow forecasting insights using deep learning models and evolutionary optimisation. Many recent efforts to improve streamflow predictions have used hybrid methods that combine DL and ML models with optimisation. They compare three DL models for streamflow forecasting at two Algerian stations using various lag durations in their research. The PSO automatically selected hyper parameters using adaptive moment estimation [26].

K. Bavarinos et al. (2021) presented maximum-power-point-tracking using reinforcement-learning and evolutionary optimisation. Only those parameters needed to be known. The recommended methods were compared to Fuzzy Logic to demonstrate their generalisability. Two evolutionary optimisation methods were employed after approaches were constructed and evaluated. Using either evolutionary approach enhanced energy production and lowered MPP monitoring time [27].

Y. Jia et al. (2022) offer CroApp, an edge computing resource allocation optimisation tool based on CNNs. We optimise resource efficiency and distribute jobs appropriately to solve the computational problems of processing IoT data at the edge. Even if the technique optimises resources, the extensive pre-deployment tailoring may limit its flexibility for real-time IoT applications [33].

A. D. Martinez et al. (2022) studied adaptive multi-factorial evolutionary optimisation for multi-task reinforcement learning. Comparing A-MFEA-RLs against non-evolutionary multitask reinforcement learning techniques in a variety of challenging reinforcement learning circumstances assessed the proposed method's efficacy [34].

CNNs and metaheuristic optimisation improve IoMT big data analytics (A. Sampathkumar et al., 2022). The suggested technology efficiently processes massive medical data for predictive analytics and accurate diagnosis. The approach shows potential, but it struggles with strongly skewed datasets and various IoMT devices [35].

These studies highlight CNNs' flexibility and promise for IoT concerns including localisation, threat detection, health monitoring, energy management, and resource allocation. Scalability, processing needs, and IoT environment adaptation are common obstacles. Existing research constraints and technique are shown in Table 1.

**Table 1 Limitations and Methodology Used in Existing Researches**

| S.no. | Author / Year | Title | Methodology | Limitation |
|---|---|---|---|---|
| [1] | W. Njima et al., 2019 | Deep CNN for Indoor Localization in IoT-Sensor Systems | Deep CNN model trained on high-dimensional sensor data to predict indoor locations. | Limited adaptability to dynamic IoT settings due to dependency on specific sensor configurations. |
| [2] | Logeswaran K /2019 | To classify neurological disorders, DL on natural evolution optimization has been developed. | ML, Evolutionary Optimization | Only review is made. Limited technical work is considered. |
| [3] | A. Sagheer/2020 | Spectrum allocation in Cognitive Radio networks using evolutionary multi-objective optimization based on RL | Evolutionary Optimization, DL | There is not performed in future |
| [4] | A. Kaur/2020 | Using Ensemble Learning for Evolving Optimization of Sentiment Polarity Classification in Imbalanced Multiclass Dataset. | Evolutionary Optimization | Lack of efficiency |
| [5] | S. K. Sarma, 2020 | Rider Optimization based Optimized Deep-CNN towards Attack Detection in IoT | Integration of Rider Optimization Algorithm with Deep CNN to detect anomalies in IoT. | Computational intensity limits real-time deployment in resource-constrained IoT. |
| [6] | W. N. Ismail et al., 2020 | CNN-Based Health Model for Regular Health Factors Analysis in IoMT | CNN-based model for analyzing health data from IoMT | Challenges in managing heterogeneous data sources and scalability across IoMT platforms. |
| [7] | J. R .Jian/2020 | Scouring depth of submerged weir may be | Evolutionary | Research is limited to |

| | | | | |
|---|---|---|---|---|
| | | modelled using AI that has been evolutionary tuned. | Optimization | traffic flow |
| [8] | Z. Deng et al., 2020 | Toward Efficient Image Recognition in Sensor-Based IoT | Weight initialization optimization for CNNs based on RGB influence proportion for improved image recognition. | Dependency on consistent lighting conditions and camera quality, limiting its application in diverse IoT environments. |
| [9] | T. Ghosh/2020 | Improved methodology and further-reaching findings from evolutionary approach for automated ML with focus on classifier ensembles | ML, Evolutionary Optimization | Lack of security and accuracy |
| [10] | Z. Deng et al., 2020 | Toward Efficient Image Recognition in Sensor-Based IoT | Weight initialization optimization for CNNs on RGB proportion for improved image | Dependency on consistent lighting conditions and camera quality, limiting its application in diverse IoT. |
| [24] | W. Deng/2021 | Inheritance in evolutionary biology optimization of next frontier studying computers | Evolutionary Optimization | Lack of technical work |
| [25] | K. C. Tan/2021 | Deep learning mixed with evolutionary optimization yields novel insights | Evolutionary Optimization | Performance of this research is very low |
| [26] | M. Zakhrouf / 2021 | Evolutionary optimization methods for max precise tracking of individual power points in RL | Evolutionary Optimization, DL | Did not considered Real life solution |
| [27] | K. Bavarinos/2021 | ML-Based, MDA-Informed, and Evo-Opt-Based Strategy for Bridge Maintenance Planning | Evolutionary Optimization | Need to consider optimization technique |
| [33] | Y. Jia et al., 2022 | CroApp: A CNN-Based Resource Optimization Approach in Edge Computing Environment | CNN-based approach to optimize RA and workload distribution in edge computing. | Requires significant pre-deployment tuning, reducing adaptability to real-time IoT |

| | | | | |
|---|---|---|---|---|
| | | | | applications. |
| [34] | A. D. Martinez / 2022 | Quantum reinforcement learning with evolutionary optimization | Evolutionary Optimization | Need to do more work on accuracy |
| [35] | A. Sampathkumar et al., 2022 | IoMT and Reflective Belief Design-Based Big Data Analytics with CNN-MOP | Integration of CNN with metaheuristic optimization for efficient big data analytics in IoMT. | Faces challenges in handling imbalanced datasets and seamless integration of heterogeneous IoMT. |

## 3. LIMITATION OF EXISTING RESEARCHES

Concerning CNN in IoT context, several research have been carried out. However, it is known that efficient optimisation evolution is not an easy feat. Utilising attack categorisation algorithms based on deep learning with CNN is essential. Greater accuracy and improved performance should be delivered by training and testing operations carried out using a deep learning approach like CNN mode. To achieve the ideal response, an optimisation mechanism is also essential. Filtering datasets according to ideal values would make them more efficient and accurate.

## 4. RESEARCH METHODOLOGY OF PROPOSED WORK

There have been a lot of research done on topic of data security in IoT settings, so you can rest certain that your data is in good hands. In spite of this, it has come to light that keeping up with the development of massive volumes of data is a challenging undertaking. As is the case with many other tasks, attack categorization requires the application of deep learning algorithms like CNN model. In addition, an optimization method is required to get an optimum result. This is crucial for the deep learning technique based CNN model's training and testing processes to provide better accuracy and performance. Figure 9 illustrates how filtering dataset on the grounds of optimal value might lead to improved precision and performance.

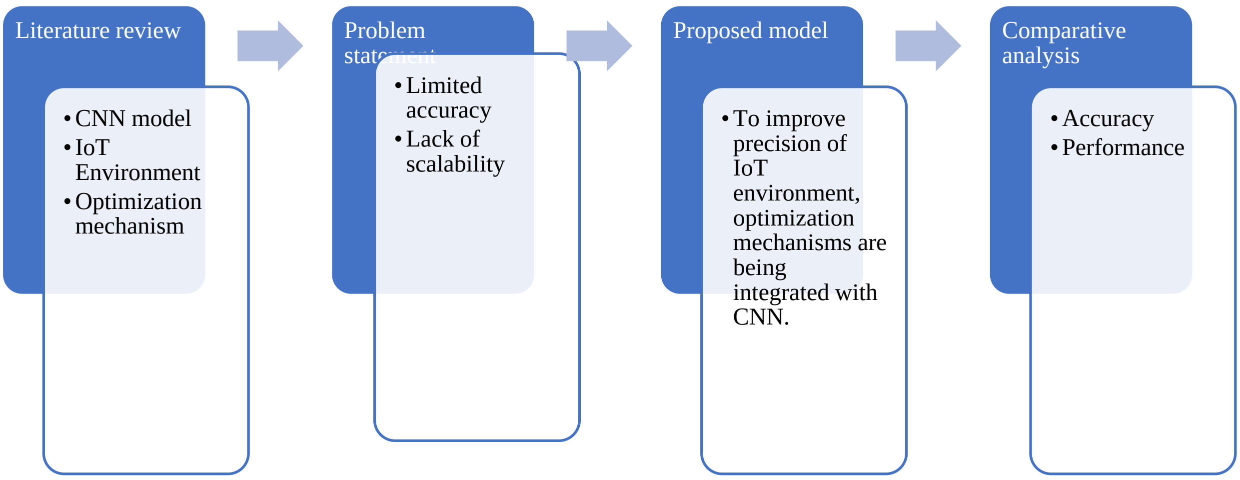


**Fig 9 Proposed Research Methodologies**

Remember that the suggested model considers the past transactions including vast amounts of data in an IoT environment. To guarantee the best possible result, an optimisation approach was used. In order to get the optimum answer, the dataset is filtered. In Figure 10, you can see the research procedure.

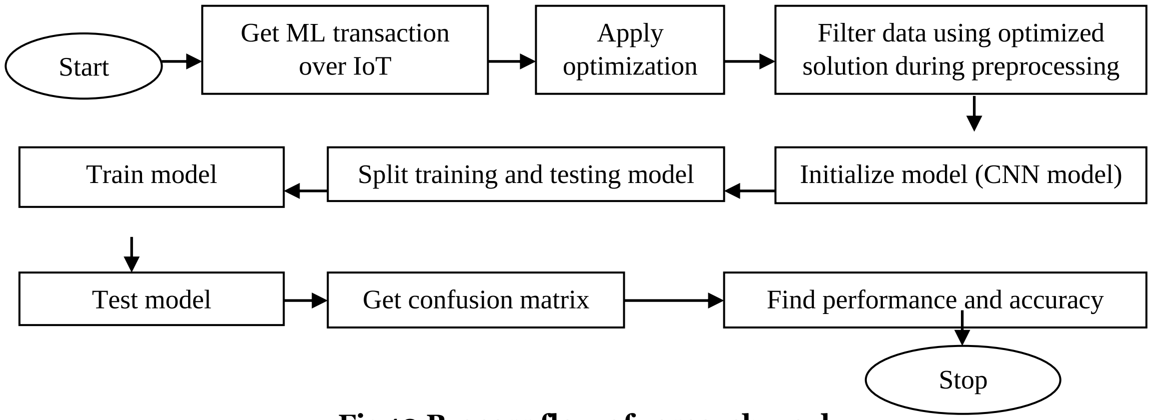


**Fig 10 Process flow of research work**

## 5. SIMULATION OF PROPOSED WORK

The suggested study makes use of deep model applied to data including several CNN entries in IoT setting. This makes it possible to detect and categorise hybrid designs. Two scenarios have been simulated at this point: one in which the dataset is filtered, and another in which it is not. Improved detection and classification performance should result from applying optimizer to dataset to filter it.

### 5.1 Confusion matrix in case of conventional model

We describe the standard model's accuracy in this section. Both Table 2 and Table 3 provide confusion matrices from conventional model testing, and Table 3 shows an accuracy table generated from Table 2.

**Table 2** Confusion matrix of conventional model

| | **Case 1** | **Case 2** | **Case 3** | **Case 4** |
|---|---|---|---|---|
| **Case 1** | 874 | 34 | 49 | 43 |
| **Case 2** | 31 | 899 | 24 | 46 |
| **Case 3** | 49 | 81 | 841 | 29 |
| **Case 4** | 32 | 37 | 30 | 901 |

**Results**

TP: 3515 and Overall Accuracy: 87.88%

Table 3 displays the retrieved accuracy parameters from table 2 by the use of the confusion matrix.

**Table 3** Accuracy parameters for conventional model

| **Class** | **n (truth)** | **n (classified)** | **Accuracy** |
|---|---|---|---|
| **1** | 986 | 1000 | 94.05% |
| **2** | 1051 | 1000 | 93.68% |
| **3** | 944 | 1000 | 93.45% |
| **4** | 1019 | 1000 | 94.58% |

### 5.2 Confusion matrix of proposed work

In this part, we detail precision of suggested model. After testing suggested model, a confusion matrix was constructed (table 4), and a subsequent accuracy table (table 5) was generated. The suggested work confusion matrix is taken into account in Table 4.

**Table 4.** Confusion matrix for proposed model

| | Brute force attack | Man in middle | Denial of services | Sql injection |
|---|---|---|---|---|
| **Brute force attack** | 901 | 24 | 39 | 36 |
| **Man in middle** | 21 | 926 | 17 | 36 |
| **Denial of services** | 39 | 31 | 908 | 22 |
| **Sql injection** | 22 | 24 | 15 | 939 |

**Results**

TP: 3674 and Overall Accuracy: 91.85%

The accuracy metrics that were returned after applying F1-score, recall, precision, and accuracy to table 4 are shown in table 5.

**Table 5** Accuracy of Confusion matrix of proposed model

| Class | n (truth) | n (classified) | Accuracy |
|---|---|---|---|
| **1** | 983 | 1000 | 95.48% |
| **2** | 1005 | 1000 | 96.18% |
| **3** | 979 | 1000 | 95.93% |
| **4** | 1033 | 1000 | 96.13% |

### 5.3 Comparative Analysis

#### 5.3.1 Accuracy

Classes 1, 2, 3, 4 have their findings for comparing actual to planned work shown in Table 6. When compared to the gold standard, the proposed approach has been determined to be reliable.

**Table 6** Comparison of Accuracy

| Class | Conventional model | Proposed model |
|---|---|---|
| **1** | 94.05% | 95.48% |
| **2** | 93.68% | 96.18% |
| **3** | 93.45% | 95.93% |
| **4** | 94.58% | 96.13% |

By referencing table 6, the authors of Figure 11 were able to illustrate superior accuracy of their suggested model over status quo.

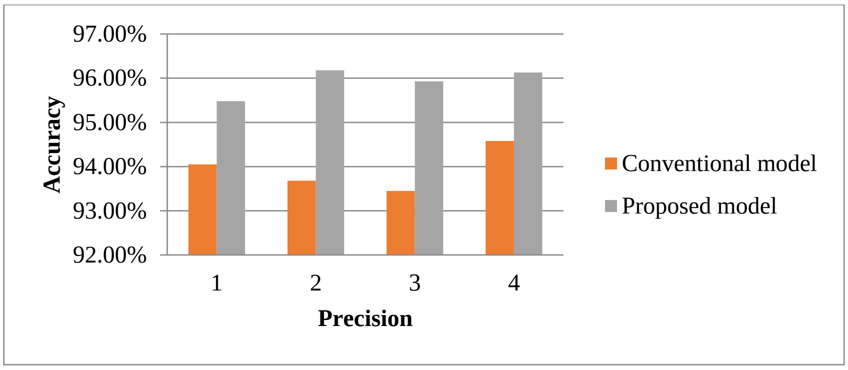


**Fig 11** Comparison of Accuracy

### 5.3.2 Error rate

Class 1, 2, 3, and 4's error rates compared to their projected rates are shown in Table 7. When compared to the gold standard, the proposed approach has been determined to be reliable.

**Table 7** Comparison Analysis of error

| Class | Conventional model | Proposed model |
|---|---|---|
| **1** | 5.95% | 4.52% |
| **2** | 6.32% | 3.82% |
| **3** | 6.55% | 4.07% |
| **4** | 5.42% | 3.87% |

Using data in table 7, we can see deviation of suggested model from the standard model in figure 12.

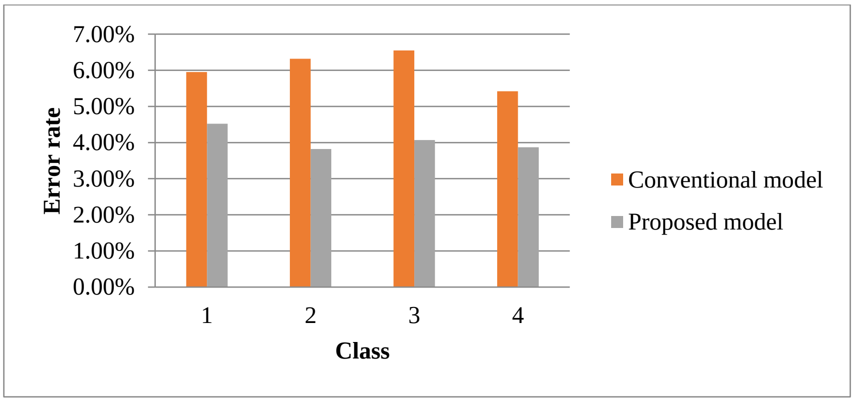


**Fig 12** Comparison Analysis of Error

### 5.3.3 Performance comparison

The outcomes of comparing actual and expected performance on previous and future tasks are shown in Table 8. When compared to the gold standard, the proposed approach has been determined to be reliable.

**Table 8** Comparison Analysis of Performance

| Case | Conventional | Proposed |
|---|---|---|
| 1 | 9.2 | 9.1 |
| 2 | 7.1 | 6.9 |
| 3 | 2.7 | 2.6 |
| 4 | 7.2 | 6.4 |
| 5 | 4.3 | 3.6 |
| 6 | 9.5 | 8.9 |
| 7 | 0.4 | 0.1 |
| 8 | 0.1 | 0.0 |
| 9 | 6.9 | 6.7 |
| 10 | 0.3 | 0.2 |
| 11 | 2.2 | 2.1 |
| 12 | 1.8 | 0.9 |
| 13 | 8.6 | 7.8 |
| 14 | 4.1 | 3.2 |
| 15 | 4.2 | 3.7 |

Figure 13 is a visual representation of table 8 illustrating superior performance of suggested model over baseline model.

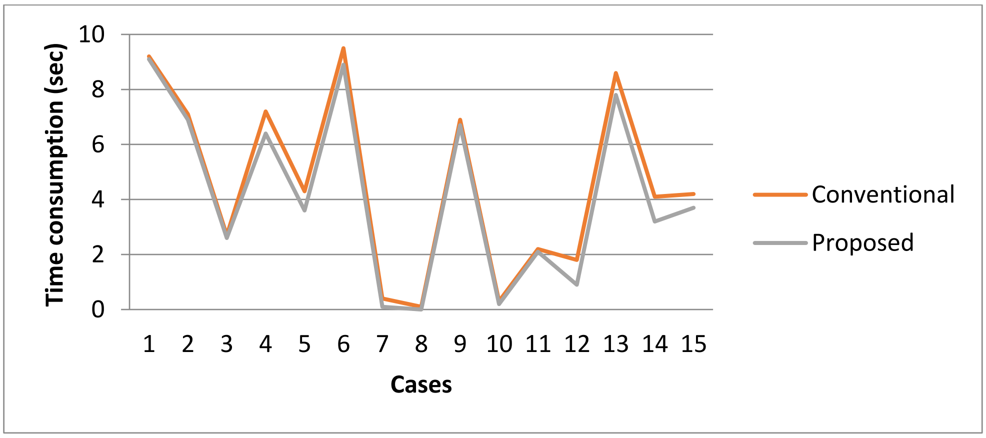


**Fig 13** Comparison Analysis of Performance

## 6. CONCLUSION AND FUTURE SCOPE

IoT allows remote access and control of numerous physical objects. This system gives cars, buildings, and other objects computers, software, sensors, and a network. This lets objects interact and collaborate in new ways. CNN model tests whether computers can learn prediction. CNN is vital to the daily operations of several global companies, including Facebook, Google, and Uber. Company after company is using CNN model to remain ahead. Evolutionary algorithms assume creatures adapt to satisfy their environmental demands. Evolutionary algorithms pick the best answer among multiple options. Nature and chance guide Evolutionary Computation (EC) methodologies to optimum optimisation solutions. They may cope with complex challenges in practical contexts effectively. Modern AI/Computational Intelligence incorporates Evolutionary Algorithms as a subset of

Evolutionary Computation. Whether EA is CNN is a disputed issue. CNN model-based evolutionary deep learning uses evolutionary computing and neural networks. Complete DL systems may be automated and new methodologies and architectures found using this revolutionary technology. NP-Hard problems and other problems that take too long to examine thoroughly may benefit from evolutionary algorithms.

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