# Artificial Intelligence based Improved Accuracy Model for Edge Computing, and IoT

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## Abstract.

The paper critically analyzes the use of Artificial Intelligence in Big data, IoT, AI, and Cloud Computing. The following paper discusses the basics of artificial intelligence that is being used in Big data and AI. All the methods that are being used currently in the fields of 5G and Iot are discussed. The involvement of Artificial Intelligence in these fields has increased and how AI is being used in these fields has been discussed. A model has also been proposed in the following paper to predict the failure rate of the industrial pump just to showcase the connection of AI and IoT

**Keywords**. *AI,Cloud Storage,Edge Computing,Cloud Storage, IoT.*

## 1. INTRODUCTION

5G Plus is AT&T's moniker for its 5G mmwave infrastructure (mm-wave). If you hear carriers prompt above 1 Gbps, or download whole movies in one minute or seasons, it's 5G. Edge Computing computes at and near the data source, without relying on the cloud for a dozen data centers. It's not going to go to the cloud. This isn't. It means you've got the cloud. Cloud storage allows you to store your data and files off-site over either the public Internet or a particular private network link. Computer hard discs can only store a limited amount of data. The files must be transferred to external storage devices for users who run out of storage. The Internet of Items (IoT) refers to the interlinked array of things connected to the internet that may collect and transfer data via a wireless network without the intervention of people. There are endless options for people or businesses. Artificial intelligence in various areas can be used to increase safety, speed, and productivity. When the data is being crunched soon, the usage of AI appears like a viable choice for maintaining and reading and analyzing this huge quantity of information. AI can also be integrated with prediction systems used for various network and data organizations [1,2]. While there were numerous competing standards in second, third, and maybe even early versions of fourth-generation wireless standards, the industry has shifted to 4G with long-term evolution (LTE) as specified by the industry organization 3GPP [3]. In most cases, performance goals for wireless capabilities, such as data speeds, coverage, and capacity, are determined globally by a consortium of operators, vendors, and countries in the International Telecommunications Union (ITU). Such user criteria were initially established by the ITU in the late 1990s for the year2000, in a specification known as IMT-2000, upon which the 3G standards were produced. The most recent ITU criteria, known as IMT-2020, are for the year 2020 and outline the user requested requirements for 5G, for which 3GPP is preparing technical specifications.

IfAI will be successful then eventually we will not require a cell phone, smartwatch, or any other smart electronic equipment to access this linked network. The countless applications that we have created would turn into a virtual, networked environment as we place them on our bodies [5].One major advance forward is made conceivable by this: artificial intelligence. Artificial intelligence will work with the ongoing organizations to arrange exchanges to guarantee that all collaborations get the top-tier administration quality from their associations [6]. The entirety of this is made conceivable by one huge advance forward: artificial intelligence. Computer-based intelligence will permit ongoing organization interchanges, guaranteeing that the best conceivable nature of administration from the accessible associations is open to the entirety of its collaborations. Also, these organizations will exist across all boundaries and areas [7]. Allow us to consider, an AI-coordinated retail organization could give customers a quicker item revelation, bringing about a lot more noteworthy request esteems prompting transformation rates in their association's shopping site. In business, an artificial intelligence-based organization can check a large number of papers in minutes to help clinicians in settling on better-educated patient consideration decisions. In the meantime, consider focus networks thatutilization AI can course and serve shopper requests all the more precisely and rapidly [8].

Since the innovation has dispatched the circulation of assets in long haul improvement (LTE) networks was a test. To tackle remote range limitations in 5G, new profound learning ways to deal with reproduce asset assignment challenges in LTE-U Small Base Station (SBS) represent LTE and LTE concurrence. Thought of the upgrade learning strategy dependent on long haul (RL-LS) memory cells to effectively appropriate LTE-U assets all through the unlicensed range to accomplish their commitments. Moreover, support learning has assumed a significant part in heterogeneous organizations, permitting Femto Cells (FCs) to self-governing and deftly recognize the radio climate and change their settings to fulfill the particular nature of administration prerequisites [9]. Al Naimi et al. shown that by using support learning for femtocell self-design dependent on powerful learning games for a completely dispersed multi-target technique, the intra-and between impedance can be fundamentally diminished. Estimating impact and reconfiguration during preparing was used as a 'learning cost'. FCS can utilize this self-putting together capacity to pick the accessible range dependent on mastered using models for artful usage [10].

## Unsupervised learning in wireless Communication (5g) [11]:-

Unsupervised learning has an unlabelled training data set, and the machine tries to work without being supervised. This approach is very effective when groups with similar features need to be detected. We do not direct the algorithm to try to discover groupings of related qualities at any stage; without assistance, the algorithm solves this relationshipA common unmonitored learning approach is the clustering of the K-means; several writers studied the applications in the next-generation wireless network system of that particular clustering technique. The cooperation spectrum-sensing technique was suggested by Sobabe et al, which was combined with an improved version of the Gaussian Mixture Model (EM) clustering, and the EM (EM) algorithm. Their study algorithm was shown to exceed the vector-based energy method. Song et al. addressed how the Kmeans algorithm may help choose an effective relay selection from urban networks by grouping and classification skills [12] [13].

In directed learning, each example should be doled out to the appropriate name. The point is to prepare a learning model on a bunch of known ideal issue circumstances and afterward utilize the model to discover streamlined answers for new occurrences. The expectation of a mathematical objective worth given a bunch of indicators is an ordinary goal of directed schooling. This job description is referred to as regression [14].To satisfy the increased traffic requirements LTE tiny cells are more and more used in 5G networks. These tiny cells include their unexpected and dynamic patterns of interference, which grow the requirement for answers that are self-sustainable which can result in higher data rates, and cheaper operator charges. Self-organizing (SON) networks are to be learned in diverse contexts and adapted dynamically. Several AI-based remedies were suggested to determine optimum network design in SONs.Transfer Learning is a common approach for the classification of vectors. In essence, a convoluted neural network (CNN) would be trained in a big dataset such as ImageNet[8], then CNN on a separate vector data set would be fine-tuned. The fortunate aspect here is that some individuals that give the learned weights for public study already conduct the training on the huge dataset. Hence, it is done by retraining with the added or changed data set to adjust the model to temporal changes [15].

**Cloud Storage:-**Cloud storage enables data and files to be saved in an offsite place accessed via a private network or a public Internet link. Data you move from your site to your storage is a third-party cloud provider's responsibility [16].

**ArtificialIntelligence in Cloud Storage:-** Converging of distributed computing and AI will permit clients to store information, yet in addition to investigate it and make determinations from it. Throughout the long term organizations like Microsoft, IBM, Google, and Amazon have put colossally in AI, particularly in the cloud programming arrangements. In the current situation cloud-AI is recognized as the accompanying significant sub-gatherings: AI cloud benefits: The joining of AI in the cloud is known as the keen cloud. Utilizing ML cloud administrations, aside from putting away and organizing clients can apply AI calculations productively and in relatively less time. Following are a portion of the conspicuous AI applications in the cloud:McKinsey has researched to investigate the influence of AI on value creation in a variety of businesses. Moreover, generally, than 15.4 billion dollars per year might be expected to have an impact from McKinsey [17].The main point of adding artificial intelligence in these sectors is to predict the data and automate it like in the case of cloud storage it can be said that AI is used to store data in such a way that it takes the least amount of space in the storage and when the request for data showing is received it can be decoded in such a speed that user doesn’t feel a dealy and user experience isn’t hindered along with less use of storage.

**Edge Computing:-**One of the biggest difficulties and potential for 5G and next-generation networks is URLLC use cases. Network resources must be distributed closer to consumers and devices to reduce end-to-end network latency and improve dependability. The disaggregated system architecture allows for the deployment of 5G CN and RAN functions at multiple sites to reduce latency. Edge computing is required to exploit the benefits of 5G architectural flexibility to meet the needs of the URLLC class of services.Edge computing helps network operators save money by lowering backhaul traffic and maximizing the utilization of central office resources. The quality of experience for end-users will be improved as a result of faster response times and increased network dependability. Third-party developers will have access to real-time network data via open network APIs, allowing them to create new apps [18].

## In edge AI with Federated Learning[19]:-

The quantity of training data that must be transmitted to edges or clouds is sensitive to the privacy and may result in possible privacy breaches, increasing the burden of uplinking wireless channels. Along with the pros of federated learning their are its cons. The following tableshows the pros and cons of various types of learning.

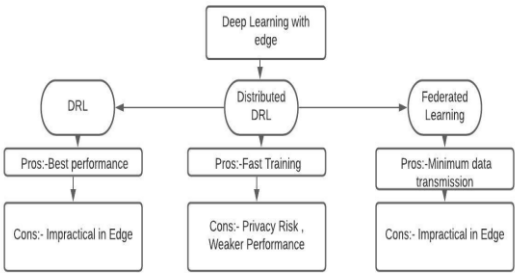



Fig 1: Deep learning with edge

| DNN Model | Application | End Devices |
|---|---|---|
| SVM/CNN | Image and Video Analysis | Movidius |
| CNN | Image and Video Analysis, Robotics | Jetson TX1 |
| YOLO | Image Recognition, Robotics | Jetson TX2 |
| AlexNet | Image Classification | Nvidia Tegra K1 |
| CNN | Image Analysis | Neuflow |
| CNN/DNN | Image Recognition | DianNao |
| CNN | Vision Processing | ShiDianNao |

Fig. 2 Edge computing artificial intelligence (AI) accelerator devices:-

**Why Artificial Intelligence in Edge Computing[20]:-**Deep learning optimization and forecasts take quite a while to converge on results, which is not appropriate for mobile border systems, in particular, the edge computing system-level tasks which demand quick answers in the millisecond scale. Artificial Intelligence in IoT: - Conveying web AI on Thing gadgets diminishes network blockage by permitting information sources to be determined close by, ensuring information transfer protection, and diminishing battery utilization for consistent remote association with entryways and cloud workers [21]. The objective of this exploration was to examine the principle methods that empower AI model execution in the Internet of Things worldview for low-execution equipment. The arrangements gave in the past part permit us to play out the AI calculation on end gadgets yet it is as yet hard to build solid DNNs on little gadgets. In specific examples, computations should be moved to all the more impressive elements from end gadgets. Since the edge worker is easy to use, it very well may be the best method to tackle the calculation issues at the best time. Having AI initiated IoT gadgets will additionally prompt fewer income misfortunes and higher existence of these items as they would improve care with the AI disappointment forecast model.The Internet of Things or IoT alludes to the various actual gadgets that encompass us and are associated with the Internet. These gadgets are associated with one another and trade information, trade information and gather information. This load of gadgets is associated or interfaced with one another utilizing a special referred to identifier as a UID. The "things" in the Internet of Things can be anything, incorporating individuals with heart checking inserts that can send constant information for investigation, or vehicles with sensors that can caution the driver in case of a potential fender bender.Various types are used in iot to speed up the process of data exchanging between the server and the devices moreover a high flow of data requires a very strong network [22].

## Training Algorithms for IoT devices[24]:-

One of the main work in the model created for the IoT devices would be the speed then the accuracy as the model had to fast so that it can exchange the data between the servers. The high network connection cost is a bottleneck in the training model, therefore local edge training is required.When the layer is coevolutionary, the input layer is separated by the BODP technique. By decreasing the input size, BODP lowers the calculation. The layer entry is allocated to various work nodes (mobile devices) to identify completely linked layers to ensure the shortest running time. In this example, because the external scenario is pretrained, the Network does not modify its weight. Even though the edge system is hierarchical in design, training between peer edge systems and the cloud can be distributed [25].

## II. PROPOSED MODEL

1.1. Problem Statement: Industrial IoT maintenance and trying to predict the failure of the device.

1.2. Model: Illustration of a typical scenario of industrial IoT maintenance. By applying statistical modeling and data visualization, we try to analyze failure performance and predict key industrial equipment such as boilers, pumps, and motors, etc. to manage their repair, maintenance, and optimal performance [26], [37-42].

1.3. Code:-The link of the jyputer network in which the code has been written is available on the link provided above. All of the code has been written in the google collab because of their better GPU accelerating system. The main objective of the code is to find the best classifier or a model to predict the failure of the pump, for this, we have used different classifiers (basically pretrained model) and tested them with various parameters that can be used in this classifier just to find the best of them [27].

1.4. Libraries Used:- There are a few libraries used for this model namely, Numpy is also used which carries out all the scientific calculations along with XGBoost which is an implementation of a gradient boost decision tree developed for speed and performance. Matplotlib library has been used to plot the graphs. Other classifiers have also been used in the below program and they are mentioned in their particular code. Preprocessing library has also been used in order to convert the string data into either int or float [28].

1.5. Dataset:-1-Contains 220314 readings by 51 sensors taken at an interval of 1 minute over 5 months for a large-scale industrial pump. The 2-Each sensor makes some important measurements used to determine the working condition of the pump, like vibration, operative voltage, current drawn, heat generated, RPM, etc.

3-The column 'machine_status' indicates the current working condition of the pump. If it is 0, it indicates that the pump is working as expected. If it is 1, the pump is malfunctioning and needs repair.The following graph shows machine failure rate at different points (1 representing the failure) it represents all the data that is present in the dataset [29].

1.6. Classifier:-A classifier is a sort of machine learning algorithm used in data science to assign a class label to data input. Classifier algorithms utilize advanced mathematical and statistical approaches to produce forecasts of the probability that a certain data entry will be categorized.I have taken these following models because its easy to find the prediction and the accuracy of the model and find it soverall score and the rmse error [30].

XGBoost:-
An open-source library that is used with the python language (in our case but the framework is supported by other languages too). It is one of the most precise classifiers out there providing a boost in the gradient. As in the following figure, it can be seen that the model score is 1which means the model has 100 percent accuracy, in this case, various parameters like n_estimators can change the score of the models, other things can be changed to increase the accuracy. Like in my case n_estimators when taken at default give a better score than taking n_estimators at 1000.

```
import numpy as np
import math
import seaborn as sn
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import train_test_split
from sklearn import metrics
from sklearn.tree import export_graphviz
from sklearn.externals.six import StringIO
from IPython.display import Image
import pydotplus
from sklearn.preprocessing import MinMaxScaler
```

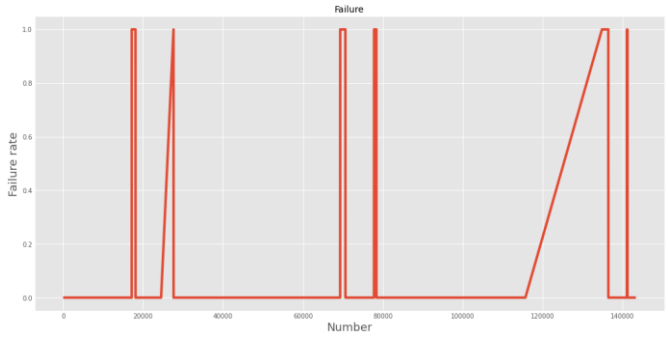
Fig 3:Libraries used in the model

```
sensor_data = pd.read_csv("sensor.csv")
sensor_data = sensor_data.dropna()
print(sensor_data)
```

```
        ID  sensor_00  sensor_01  ...  sensor_50  machine_status     timestamp
0        1   2.465394   47.09201  ...   201.3889             0.0  01-04-18 0:00
1        2   2.465394   47.09201  ...   201.3889             0.0  01-04-18 0:01
2        3   2.444734   47.35243  ...   203.7037             0.0  01-04-18 0:02
3        4   2.460474   47.09201  ...   203.1250             0.0  01-04-18 0:03
4        5   2.445718   47.13541  ...   201.3889             0.0  01-04-18 0:04
...    ...        ...        ...  ...        ...             ...            ...
4901  4902   2.424074   52.30035  ...   168.4028             0.0  04-04-18 9:41
4902  4903   2.415220   52.30035  ...   168.9815             0.0  04-04-18 9:42
4903  4904   2.427026   52.34375  ...   169.5602             0.0  04-04-18 9:43
4904  4905   2.414236   52.34375  ...   169.2708             0.0  04-04-18 9:44
4905  4906   2.419155   52.30035  ...   168.1134             0.0  04-04-18 9:45

[4876 rows x 54 columns]
```

Fig 4:Data heads




```
from xgboost import XGBClassifier
model = XGBClassifier(n_estimators=1000)
model.fit(X_train, y_train)
model.score(X_test , y_test)
```

```
1.0
```

Fig 5:Graph for visualizing dataFig 6:XGBoost Classifier

**KNN Classifier:-**It is straightforward to execute and comprehend but has a big disadvantage because the bulk of these data in use increases substantially. In our case, this model score is 1.0 but when taking the default model the score goes down to 98.8 so taking the nearest neighbors as 50, taking metric as 'Minkowski, and p as 2 gives the highest accuracy [31].

```
from sklearn.neighbors import KNeighborsClassifier
classifier= KNeighborsClassifier(n_neighbors=50, metric='minkowski', p=2 )
classifier.fit(X_train, y_train)
classifier.score(X_test,y_test)
```

```
1.0
```

Fig 8:KNN Classifier

```
[22] from sklearn.naive_bayes import GaussianNB
clf = GaussianNB()
clf.fit(X_train, y_train)
clf.score(X_test,y_test)
```

```
0.9839630562552477
```

Fig. 9: Gaussioan NB

**Gaussian NB:-**A specific type of NB is a Gaussian Naive Baye algorithm. It is employed especially when the characteristics are continuous. It is also supposed that all features are gaussian, i.e., normal distribution. Among all the three classifier this gives the least accuracy probably due to being a little old then other two. Using the default parameters in this case gave the highest accuracy.

### *1.7. Prediction:-Every one of the charts plotted with the assistance of matplotlib [32].*

**XGBoost(Highest accurate one):-**Code for plotting the graph.

```
plt.figure(figsize=(16,8))
plt.title('Predictions')
plt.plot(predictions)
plt.legend(['predictions'],loc='lower right')
plt.show()
```

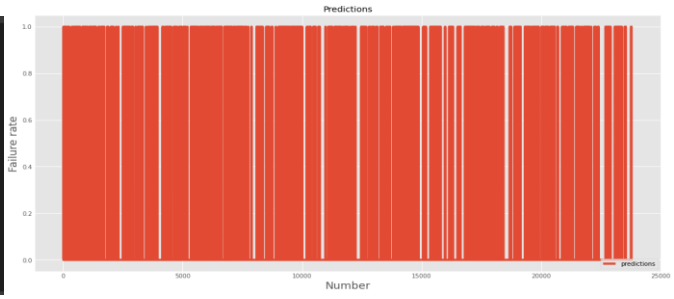



Fig 11 :Prediction using XGBoostFig 10:Code for plotting graph for predictions made by XGBoost

**Plot for the prediction(xgboost):-**

Prediction graph of Failure rate vs the index number(number of times the device was measured).The graph shows the data that has been plotted for [33]:**KNN Classifier [34][35]:-**Code for plotting the Graph.

```
plt.figure(figsize=(16,8))
plt.title('Predictions1')
plt.plot(predictions1)
plt.legend(['predictions1'],loc='lower right')
plt.show()
```

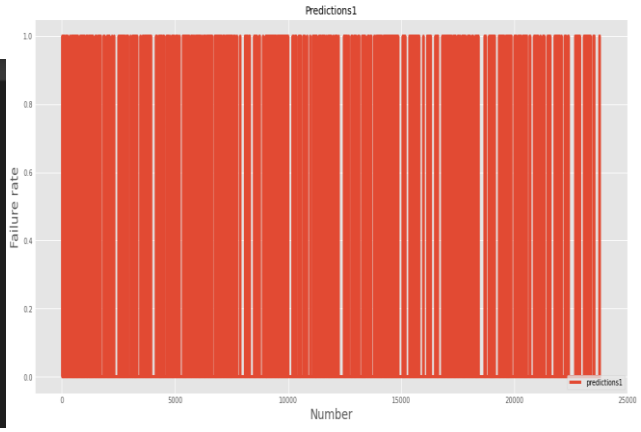



Fig 13:Prediction using KNNFig 12:Code for plotting predictions using KNN

**Plot for the prediction:-**Prediction graph of Failure rate vs the index number(number of times the device was measured)

- **Gaussian NB(Second Highest accuracy):-**Code for plotting the Graph.

```
plt.figure(figsize=(16,8))
plt.title('Predictions2')
plt.plot(predictions2)
plt.legend(['predictions2'],loc='lower right')
plt.show()
```

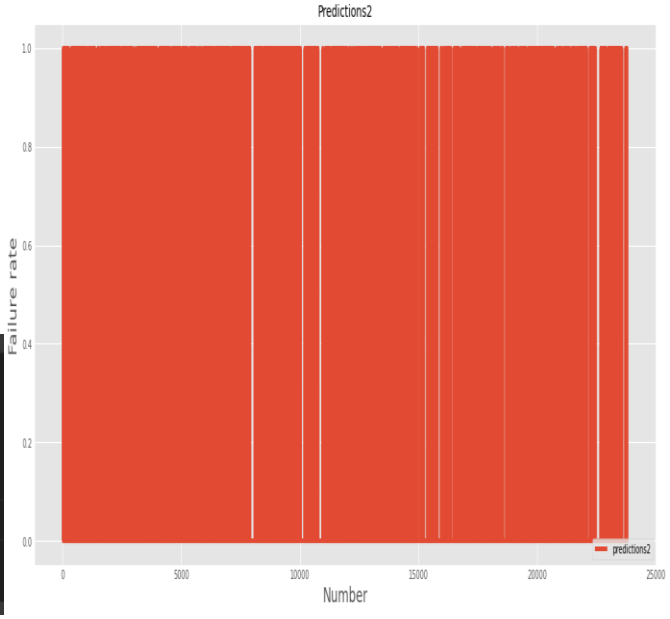



Fig 15:Prediction using Gaussian NB

Fig 14:Prediction using Gaussian NB

**Plot for the prediction:-**Prediction graph of Failure rate vs the index number(number of times the device was measured)

### 1.8. Analysis:-The following code has been used to plot the graph.

```
plt.figure(figsize=(16,8))
plt.title('Predictions1')
plt.plot(y_test1)
plt.plot(predictionssmol)
plt.legend(['y_test1','predictionssmol'],loc='lower right')
plt.show()
```

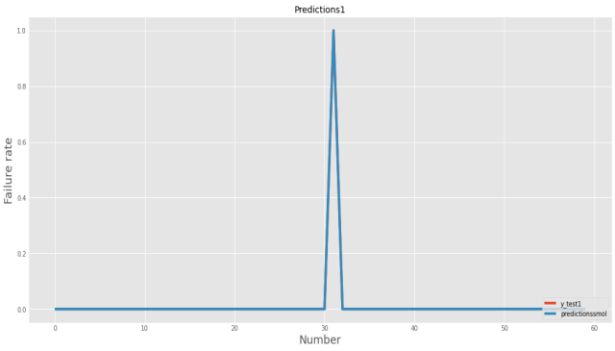



Fig 17:Prediction vs the test dataFig 16:Code for plotting the graph for analysis

The accompanying diagram shows that the expectation model is working perfectly as the predictions completely overlap the y_test graph. This graph is made with the first 60 values in the predictions and the first 60 values in the y_test just for ease of visualization. I have plotted two data y_test1 and predictionssmol which compares the 60 values only.The model has an RMSE(Root Mean Square Error) of 4.19(approx).

```
[ ] rmse = np.sqrt(np.mean(predictions - y_test)**2)
    rmse

4.198152812762384e-05
```

```
[ ] from xgboost import XGBClassifier
    model = XGBClassifier(n_estimators=1000)
    model.fit(X_train, y_train)
    model.score(X_test , y_test)

0.9999580184718724
```

**F**ig 18:Code for getting the model score of XGBoostFig 19:Rmse Value

### *1.9. Model Results:-*

A model predicting the maintenance of the Pump has been created using the three classifiers and all of them have accuracy of 98 and above. Among the three classifiers used, Xgboost has the highest accuracy this is because this classifier is a pretty new and more accurate one. bodies. From the Above analysis of the model it can be seen that all the classifiers used have an efficiency of 98 and above .

From the above, plainly Artificial Intelligence can be utilized In IoT [43-44] for different purposes for this situation it was a prediction of the failure of the particular pump. The first model classifier has the highest accuracy among all the others because that library has been developed in the recent making it a more accurate and a fast classifiers then its predecessors. This was just a small-scale model bur it can be implemented in a large-scale factory where every second of work is not being done or any failure leads to revenue loss. AI and IoT [45-48] together can be used to decrease the revenue loss and overall increase the quality of the product.

## 2. CONCLUSION

In conclusion, the research study discusses and elaborates on the promising application and scope of Artificial Intelligence in IoT, 5g, and edge technologies. It very well may be inferred that Artificial insight will be an extremely large part of IoT, 5G, Edge technologies. The growing amount of internet users just supports this argument more as AI would be helping these network providers and these IoT developing companies to maintain the accuracy of their devices while handling this large amount of data flowing through them without costing too much. A lot of money and research is being poured into this and its pace of development in this area doesn't seem to slow down. This paper also dwells on the current challenges faced regarding the implementation of artificial intelligence, some of which are born due to the lack of feasibility in fields such as 5G, where extensive training is required for real-world operations which could be very costly and time-confusing. Because computers aren't truly human, their ability to prove mathematical theorems, make a moral judgment, compose new music, or be genuinely innovative is beyond the scope of neural networks and artificial intelligence.

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