

# A STUDY ON APPLICATION OF VARIOUS ARTIFICIAL INTELLIGENCE TECHNIQUES ON INTERNET OF THINGS

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## **Abstract:**

In today's world, digitization plays an extremely prominent role in day-to-day applications. Its future deployment, needs an Internet of Things (IoT) to embrace automation, remote monitoring and predictive analysis. IoT is a device connected with an internet and it's a combined embedded technology including actuator and sensor device. Also, it encompasses, wired and wireless communication devices, and real-world physical objects connected to the internet. IoT is majorly used in diversified fields like smart classroom, smart banking, smart home, smart agriculture, smart healthcare application etc. Typically, IoT requires intelligence, to achieve the automation process in an efficient way in many applications. Artificial Intelligence (AI) paves the way to makes the IoT smarter and efficient by its approaches. Due to enormous amount of data being generated in various applications, IoT combined with Machine Learning (ML) and Deep Learning (DL) models is used to enhance the functionality in complex applications. In this survey the application of AI, ML and DL models deployed in IoT are deeply explored.

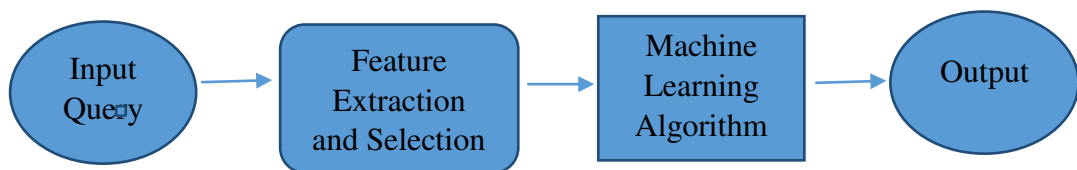
**Key words:** Internet of Things, Artificial Intelligence, Machine Learning, Deep Learning.

## **I. INTRODUCTION**

In recent years, emerging technologies and its future exploration, communication between the devices becomes much easier than endlessly before. Internet of Things (IoT) able to done an environment in smart way by means of its presence. It becoming a new dimension and abundant network paradigm facilitate transparent and distributed services. By means of IoT, it

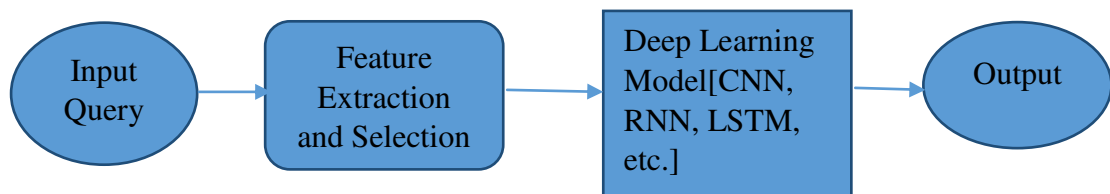
is possible to connect devices like mobile phone, air condition, television, sensor etc., to internet. According to the report of IDC statistics, there are more than 50 billion devices are connected to the internet in overall world. Its builds an environment in smart way like, everything work automatically according to user's preferences and convenience. It learns things from Internet, from that data it enhances the diagnosis, monitoring, localization, automation etc., involved in various application like medical, mechanical devices, human's nature etc.,The main purpose of IoT is to progress an environment in a smarter way and provide smart activity for human being in order to save time, manual work, energy. By means of providing enormous amount of service to users, a large number of sensors and devices are being generating massive data in order to extends IoT application in various fields (ie. All real time applications). It is based on sensor technology that able to connect millions and billions of objects to the internet. Several day-to-day activities can be done by means of this connectivity. It includes fog computing, cloud computing and edge computing. Its contribution is very wider in various applications. In such a way effective models and approaches is needed to make the environment in a smarter way. So Artificial Intelligence (AI) is introduced in IoT. Artificial Intelligence (AI) is an emerging trend of solving real world problems and its application over data science is massive. AI was invented by John McCarthy in early 1950's who is considered as the father of AI. And further exploration Alan Turing given some invention over AI by means of its contribution and he is a creator of Turing Test. Through, Decision Support System (DSS), decision making is done and a major benefit like to give transformation, i.e., manual task and time-consuming methodology to very smarter, automated and using a time in an efficient way. AI is the methodology to mimic human intelligence by using its set of predefined algorithms and its effective approaches like Meta-heuristic, Heuristic, Fuzzy Logic, Set of Inference rules etc. AI done tremendous role in day-to-day application. For instance, robotics, automation, monitoring, decision making, diagnosis, in various fields like agriculture, healthcare, finance, management etc. Its role in IoT is massive in order to provide every application in a smart way. It gives the path to intelligent, in such a way that the system can performs in an efficient way in order to avoid lagging of control, parameter analysis and various features detection etc. The main necessity of AI in IoT is to enhance that adequate volume of data being generated. Iot sensor usually send large volume of data to process in order to perform real time application, So unnecessary data has been removed and adequate data has been taken for further processing in Iot application by using AI. So the Data mining technique is being used in order to carried the data integration,

selection, cleaning, transformation, mining and pattern evaluation process. Machine Learning (ML) is the sub domain of Artificial Intelligence. In order to process the complex data, huge volume of structure ML approaches is used. It is similar to AI like to train a model or machine, in such a way that machine can perform. Its algorithms are very powerful and doing task of data processing, computation, analyzing, extraction, reduction etc in an efficient way in order to solve a real-world problem.



**Figure 1:**Flow of ML

It mainly comprises of i) supervised ii) unsupervised learning. It encompasses data monitoring. Input Query is passed to the feature extraction, by extract all its features machine learning algorithms (Association, Clustering, Classification is applied) to predict and diagnosis. After prediction, output is generated in the form of predicted as per model preferences.

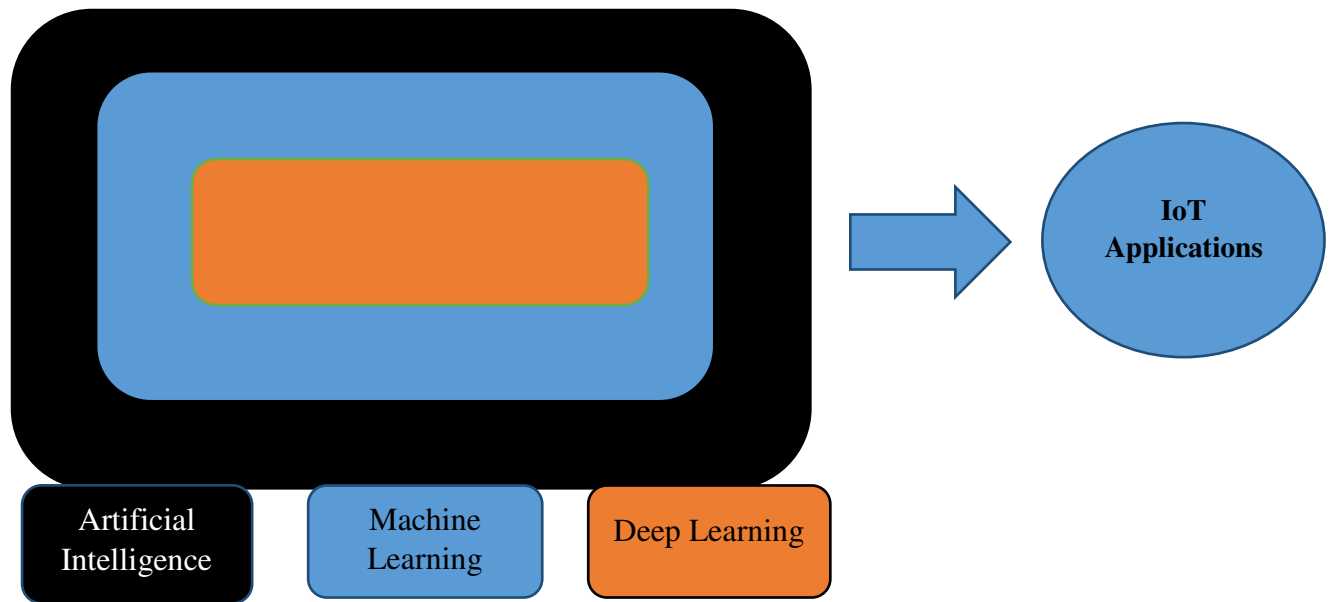


**Figure 2:**Flow of DL

When computation resources is powerful, and also time consuming is more throughout the training phase of the model. It is one of powerful challenge in DL. Instead of traditional methods, deep learning model is need for the rapid growth of very powerful hardware resources (ie. GPUs) and powerful training models made it possible in terms of analyze and process a complex problems and data. So, introduction of DL is required in the field of AI in order to achieve processing the data and approach [10].

As same way to traditional ML, DL can be classified into 2 scenarios: i) Unsupervised Learning (Unlabeled Data is used to train the model) ii) Supervised Learning (Labeled Data is used to train model). It is mainly introduced for the purpose of Recognition and Detection of text, handwriting, images, sound signal etc. Various DL model is deployed in the process of

recognition and detection [i.e., MNN(multilayer neural network), LSTM(Long Short-Term Memory), CNN(Convolution Neural Network), RNN(Recurrent Neural Network) etc.][10]



**Figure 3:** Role of AI, ML, DL in IOT application

AI, ML, DL application in Iot are widely emerging and increasing. IoT is an emerging trend and its used almost over all the application like healthcare includes (monitoring, analysis of disease), Automation(Education, Home application, Industry application), Prediction(Traffic, Driving) demonstrates in **Figure 3**. So, In these survey we focus on the comprehensive summary of how AI, ML, DL are deployed in IOT and how various model in AI, ML, DL are used for Iot application in terms of processing and functioning to tackle all real time day to day application. In this survey, the following ways has organized to follow, Section II discusses the Related Study, Section III discusses various AI, ML, DL approaches for IoT application, Section IV organizing the conclusion of these survey.

## II. RELATED STUDY

There is no specific research article is available still, only dedicated for the literature survey of both AI, ML and DL and utilizing all its approaches and models in Iot application. Very few article presents some common application between AI, ML, DL. However, it does not compare the AI, ML and DL along with IoT application. It focusses on effect of AI, ML and DL involved in the Iot over various fields like healthcare, agriculture, home automation, education etc.

Tsai et al. [37] proposed the approaches of Data Mining in which he focus to address various clustering, association, classification for Iot application and services. However, it didn't

include AI technique, it focuses much on our study. Furthermore, they only consider data mining on the offline basis, but we consider to create model for real time applications. Perera et al. [38] discussed the computing function of context aware which includes supervised and unsupervised techniques like rule, fuzzy logic etc. but it is not potential for applying in real time automation and detection system. In such a way that it responds only limited amount of action, so the role of ML and DL is needed to overcome, in order to achieve high performance. The survey of ML methods for WSN(Wireless Sensor Networks) is discussed in [39] by Alsheikh et al. He discussed routing, clustering and localization in order to consider the purpose of QOS(Quality of Service) and Security. But they did not achieve reliability factor, so the way of processing the network is comparably slow. They discussed various advantages and disadvantages of different ML and DL approaches.

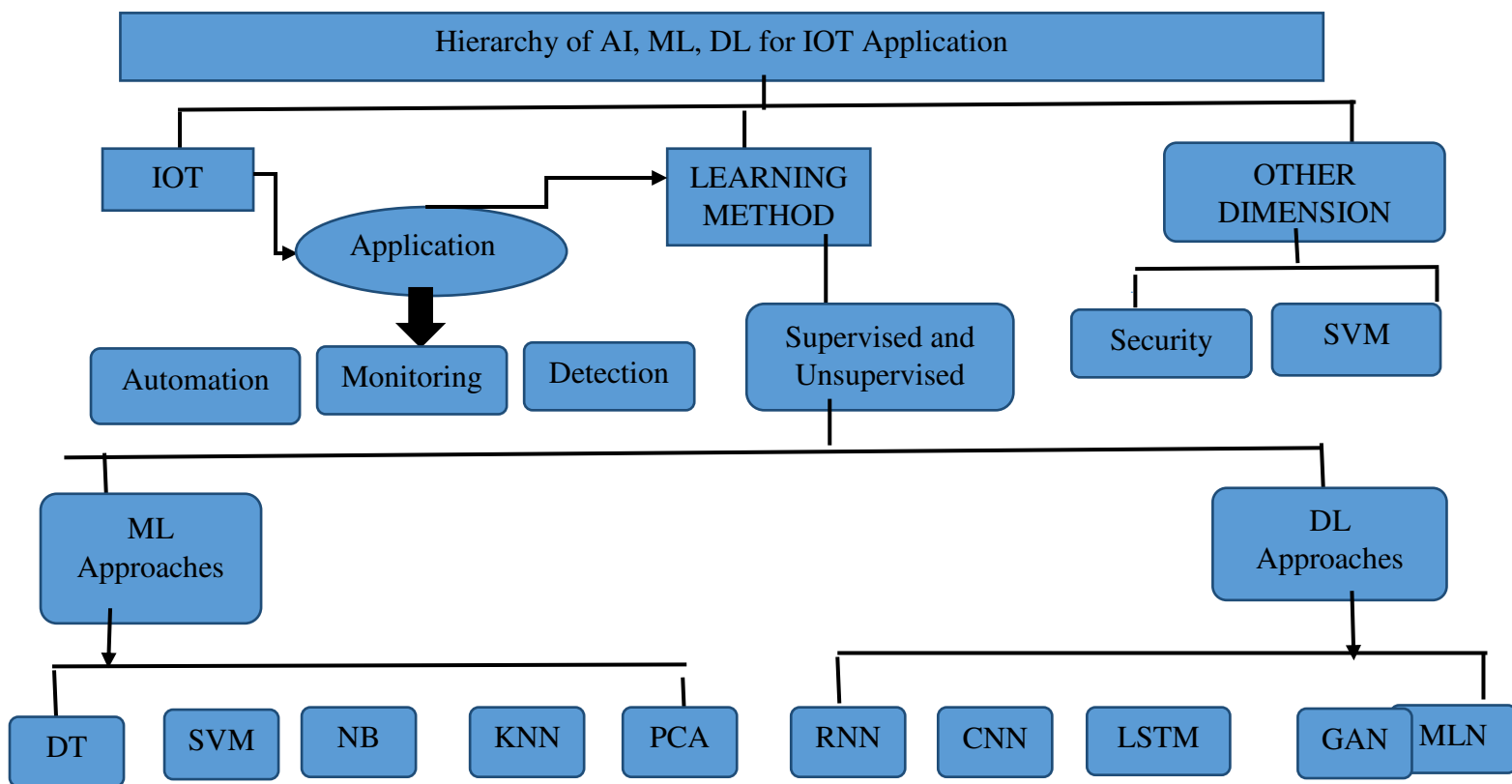
Fadlullah et al [41] addresses Traffic Control System for Network, they mainly focus on network's infrastructure and its various from our AI, ML and DL approaches also Qiu et al. [42] reviewed various traditional ML approaches along with various advanced DL techniques for process and analyze the signal processing techniques. [42-48] has reviewed and discussed various challenges and controlling mechanism for Network Security, Security in application layer, Authentication and Access Control and also shows various mechanism for handling the parameters of control.

Granjal et al[49] stressed security and issues in IoT communication and providing solutions the Communication System [IoT]. A Review on IDS[Intrusion Detection System] on IoT Application [50] by Zarpelao et al. which emphasized the various ML algorithm to protect the IoT system from vulnerability. [51] discusses the regulatory and legal approaches for finding necessity of privacy and security to satisfy the IoT framework. Roman et al. and Xiao et al. [52,54] discuss the IoT context on the basis of Distributed System also discuss various challenges, advantage and disadvantage on the basis privacy and security concern. And also implement ML model to tackle the computation issues, Security solution etc. [53] surveying the threats and vulnerable attacks involved in IoT application also discussed its pros and con.

[55,56] papers discuss with the utilization of DM and ML models to likelihood the Detection System for Cyber-security and also, they discussed the various anomaly detection to utilize the DL and ML model in cyberspace.[57,58] discuss various AI approaches in the concern view of framework related to context-aware and also discussed the implementation of various IoT systems and they did not use the DL approaches. [59,60] emphasizes the ML and DL

approaches for Iot security with respect to Network Traffic Control Systems and focuses the organization of network.

[61-64] were discussed various classical ML and DL model with respect to pattern recognition and speech processing and computer vision and also emphasized to evaluate the process of big data Application. Also develop recommendation model for provide various application in mobile advertising. [65-69] Developed DL model used in various application for analysis of data in order to perform Mobile Security, Speech recognition, Translation of language, Recognition speech etc. Also discussed 5G mobile environment and integrates that into AI and also provides various challenges and opportunities in the research direction. **Table 1** shows solution to the Problem discussed from Literature Survey and also discussed the hierarchy of AI, ML, DL for Iot in **figure 4**.



**Figure 4:** Hierarchy of AI, ML, DL for IOT Application

Reference	Methodology
[75]	To intensifying the data processing is large in order to introduce 3-tier system.
[70]	To rectify the poor network connectivity by used if HiCh architecture along CNN model and achieved a better Response Time
[71]	Using various Deep learning model, in order to processing a big data in all the application.

[72]	Using homogeneous dataset rather than using heterogeneous in order to achieve better accuracy in terms of prediction.
[73]	By means of Entropy computation, satisfies the needs for processing big data.
[74]	Additional representing function of dataset behaves on various function, on the basis of proving enormous behavior.
[76]	Providing cloud Environment in HCS, by means of PPSO, it identify the optimal solution in order get minimum computation time.
[77]	Introducing probability distribution function, so the missing values are filled with susceptible value, it gets good performance for the basis of various deep learning model and also acts as a powerful preprocessing mechanism.
[78]	Avoid unnecessary action, so the image, sound dataset can be achieved a good accuracy by applying various deep learning model.

**Table 1:** Solution to the Problem discussed in Literature Survey

### III. DESCRIPTION OF VARIOUS AI, ML, DL APPROACHES FOR IOT:

In the era of, advancement of technology Iot provides a smart environment in such a way it connected a thing between each other through Internet. Its role in today's world is tremendous and it have been doing a fabulous role in each and every day-to-day application in terms of automation, monitoring and diagnosis. In order to provide intelligence service, so AI had been introducing in the area of Iot. Further exploration of AI, MI and DL had been introducing for the way of achieving a efficient thing in a very easy way. In this section, we briefly describe about various approaches and model of (AI, ML and DL) involved in Iot and also discuss its various applications.

#### 1. Various AI approaches for Iot:

Generally Traditional approaches suffers while providing its standardization over various fields in terms of its performance, reliability, scalability. The way of proving the features is very complex and also time consuming. But, In AI everything had been systematic and follows entirely different process comprises of Data collection, Data exploration and preprocessing, Selection and conversion of data, Training and testing of model, Evaluation and deployment of model. The AI way out of the general process is given **Figure 5**.

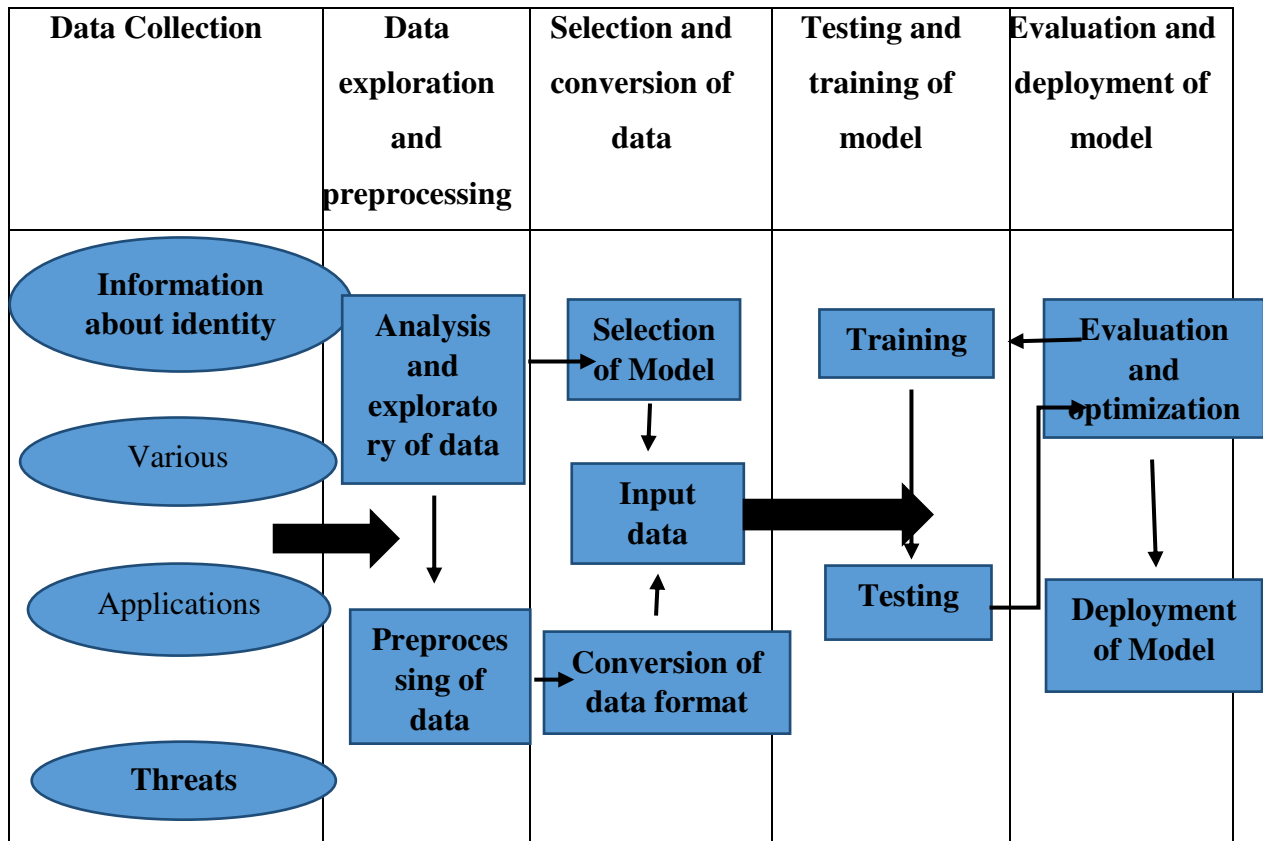


Figure 5: The AI way out of the general process

**1.1 Bayes' Theorem in AI:**

Bayes' theorem is generally said Bayesian reasoning, Bayes' rule and Bayes' law, in which it is used to determine the probability of an event with uncertain knowledge. It relates two random event of probability both conditional and marginal. It allows to update the event prediction probability rate by detecting various new information to the environment. For example, if particular disease corresponds to a similar age group, then we predict the probability of that particular disease more accurately by use of its corresponding age group.[79]

Bayesian reasoning can be predicted by using the both the conditional probability and product rule.

From the product rule, we write as,

$$P(A \wedge B) = P(A | B) P(B) \text{ or } \dots\dots\dots 1$$

In such a way, event B probability with event A(known),



$$P(A \wedge B) = P(B | A) P(A) \quad \text{----- 2}$$

Equating both 1 and 2, we get,

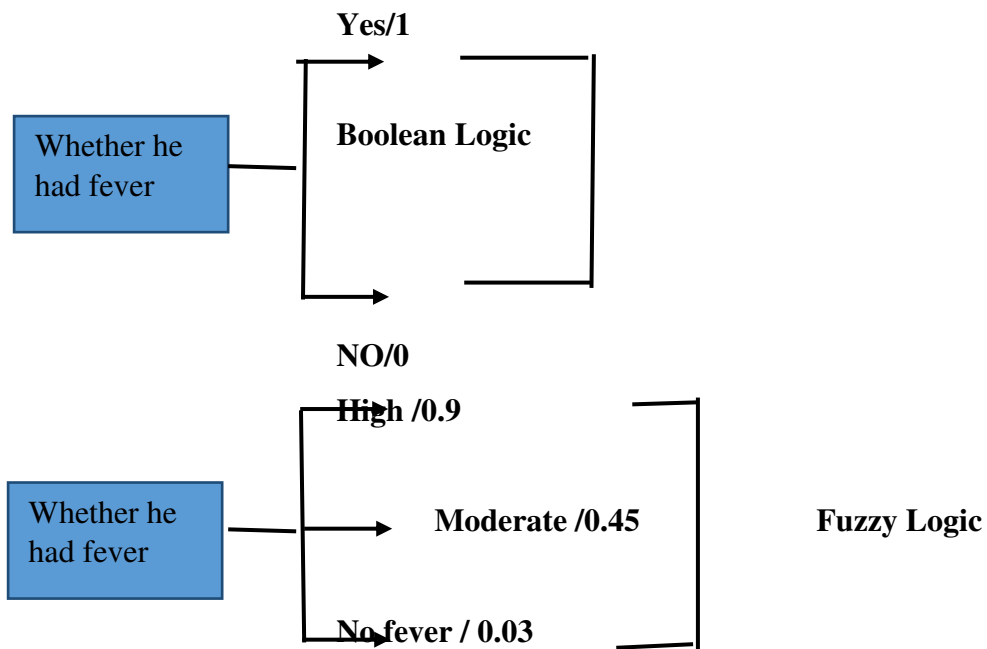
$$P(A | B) = P(B | A) P(A) / P(B) \quad \text{----- I}$$

Equation mentioned in I is known as Bayes' theorem. Also, this is a widely used modern system for approaches based on probability. It shows simple relation between conditional and joint probabilities.

$P(A | B)$  = posterior,  $P(B | A)$  = likelihood, means hypothesis is true, so calculate the probability evidence.  $P(A)$  and  $P(B)$  be known as prior and marginal probability.

### 1.2 Fuzzy Logics(FL) in AI:

FL is the reasoning methodology that more over similar to Human Reasoning. How human could take decision, in such a way fuzzy logic approach works. It Provides all the possibility between **YES** and **NO**[All the possible value between [0 to 1]].



It is a mechanism of finding the uncertainty of a particular event. Traditional system usually performs as like as human being in which like 0's or 1's which is like true or false. By FL provides uncertainty between 0-1 and also it was introduced by Lotifi Zadeh [80]. It is helpful for various real time applications like washing machine, consumer products etc. Also deals with uncertainty in engineering.

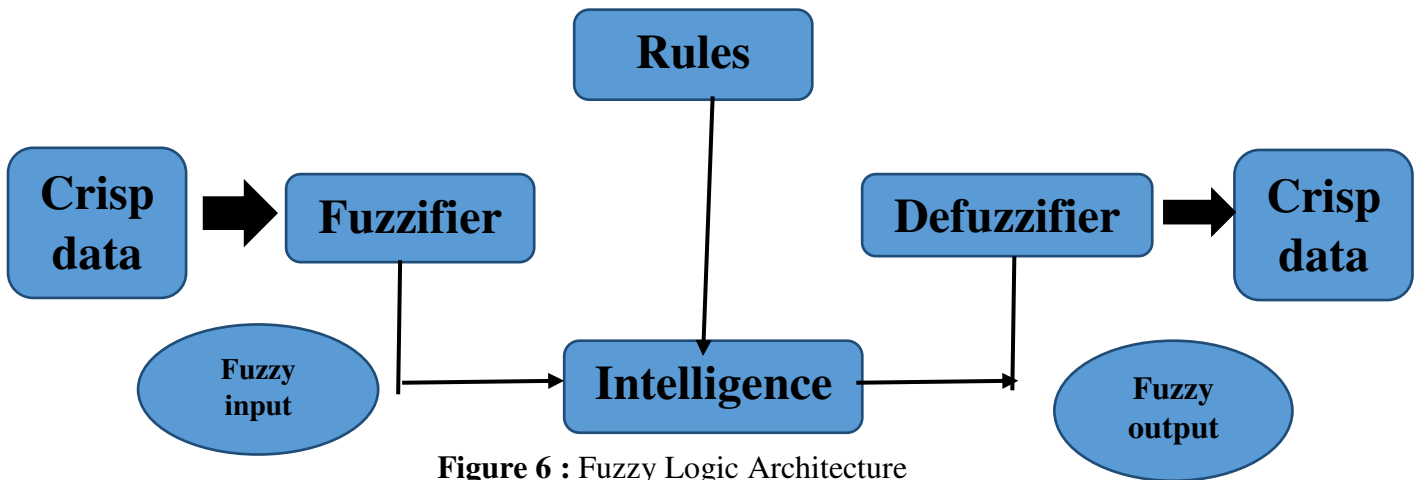


Figure 6 : Fuzzy Logic Architecture

It consist of fuzzy membership function in such a way it predict in between state of true and false. Also, various algebraic properties involved to get a crisp output. Initially crisp data is taken for fuzzifier which add membership function to crisp data and by use its rules (Fuzzy control system) decision is driven. Finally, fuzzy output is converted into crisp data out which is shown in **Figure 6**.

## 2. Various ML approaches for IOT

The existence of ML technology starting from 1950's. In early 1990's Data Driven approach [26] is make over into ML approaches. Throughout 1995-2005, this had been shifted and focused NLP (Natural Language Processing) and IR (Information Retrieval). Neural Network was tried first time in 1957 and had comeback at the time 2005. The growth is needful in ML, the factor like Technical Skill, Environment factor and Infrastructure have been a major issue.

Table 2: ML approach for IoT Application:

Type	Method Description	IOT Application	Advantage	Disadvantage
DT	Training dataset had been represented in terms of leaves and branches. The new sample's class are predicted by use of trained	IDS(Intrusion Detection) and Traffic Source.	It is very simple to implement, transparency and easy way to use.	Large Storage space is needed in order to construct the tree and understanding is not easy for cases.

	model.			
<b>NB Tree</b>	NB tree used to calculate the bayes' theorem also guess the feature set's probability. Specific label are used to provide an assumption of specific random value.	NDS(Network detection)	It is robustness in order to provide irrelevant features and simplest mechanism it very easy to implement.	It does not provide interaction between the features. It does not handle feature independent functions.
<b>SVM</b>	It formulae the feature dimension in terms of split the hyperplane into numerous classes and adjacent data point in every classes is maximum.	Detection of Malware, intrusion, and various threats and attacks.	It is known to be capability based on generalization and also for small and large number of feature attributes can be suitable	No chance of selecting kernel should be optimal. Also to interpret and understand SVM models are very difficult.
<b>KNN</b>	Based on the vote count, to select the feature vector from its nearest neighbor also decides and find the unknown data sample from its nearest neighbor.	Anomaly and intrusion Detection.	It is most powerful Detecting the Intrusion.	Determining the K(optimum value) is very difficult, it can change different from different dataset.
<b>K-means</b>	Number of	Industrial WSN's	Requirement of	While dealing the

<b>clustering</b>	Cluster are generated on the basis of k-value. In which it identifies which clusters have similar characteristics of data in order for similar features.	Detection of Sybil in antinomies.	labelled data is limited.	detection in intrusion, it is much s
<b>PCA</b>	PCA reduces the number of correlated features on basis of probability also into uncorrelated features.	Used to reduce feature, so that IoT system performs an efficient way	Used to Achieve dimensionality reduction in order to reduce complexity.	_____

### 3. DL approach for IoT Application:

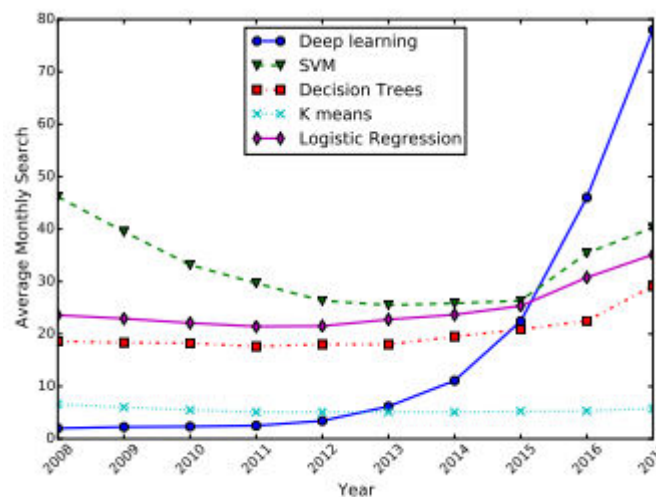
By means of various real-world application, generated an extremely numerous amounts of data. In such a way that, machine learning models are deployed in Iot Applications. Though it contribution in terms of various major fields like healthcare, automation, detection, monitoring etc. is manifold by use its various supervised learning model like (linear regression, Logistic Regression, Support Vector machine, naïve bayes, k-Nearest Neighbors) and unsupervised model like(Clustering, vector Quantization), but machine learning model are suffered while processing the numerous amount of data and image applications. In order to overcome, the processing speed, efficiency, processing diversified data in a simpler way Deep Learning (DL) model are deployed in Iot.

DL was introduced by Valentin Grigor' evich Lapa and Alexey Grigoryevich Ivakhnenko in the year 1960's. They analyzed statistically, by using some polynomial function and complex mathematical equations. In 1990's, they developed multilayer neural network was introduce and their future enhancement recognition models are made that are exactly mapped to similar data. Long Short Term Memory(LSTM) model was developed in the year 1997 and its was invented by Sepp Hochreiter and Jurgen Schmidhuber[26]. And their exploration Convolution

Neural Network (CNN), Recurrent Neural Network(RNN), Generative Adversarial Network (GAN), Self-Organizing Maps (SOM) etc. was made to enhance the advancement of day-to-day applications [27]. In today's scenario, DL application is unbelievable, without DL Data world don't exist. It is a future of data science and it paves the way for numerous inventions that would achieve tremendous result in day-to-day application.

DL comprises of a technique like supervised and unsupervised centered on numerous layers of Artificial Neural Network (ANN) that had a capability to learn categorized representations in DL Architectures. These DL Architectures comprises of numerous layers in order to pertain the output. Those numerous layers is known as hidden layer. By means of its input layer, each layer is capable of producing linear and nonlinear responses on the data. The various functions done by DL is to mimics the human brain's mechanism in such a way that signals for processing neurons.[23]

When compared to other traditional approaches in machine learning, DL models have enormous features in order to gain more attention in various fields. Such approaches are said to be semi architecture learning versions of shallow-structure (ie. Limited Subset) of DL. **Figure 4** demonstrates that, In Google trend's 5 most popular ML algorithms, in which DL becomes the most popular than the others. In past decades, even though ANNs have done a major progress



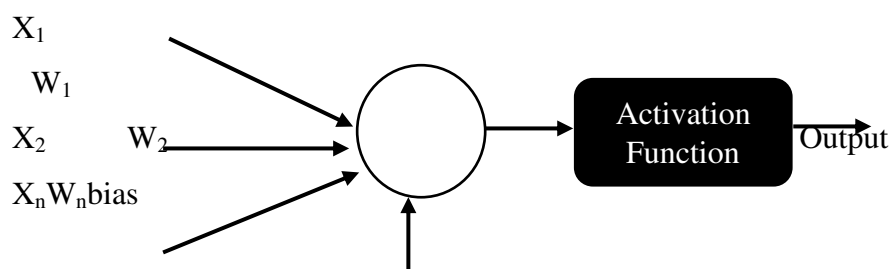
**Figure 7:** Deep learning attention towards Google Trends[23]

help of its back propagation but today's trends DNNs play a huge task in data science after 2006 stated by G. Hinton et al[28]. After that, by consideration of its performance in terms of the state-of-the-art has been witnessed in various fields of AI includes Recognition of image, Retrieval of image, Various search engines and Retrieval of information and Natural Language Processing(NLP).

On the basis of Top Traditional ANNs, DL techniques had developed. In the past decades to train a model using Forward neural network(FNN)[29], but the hidden layer is increased in order to train some desired model, so it is very difficult to train the model[30]. The result of Over-fitting model is due to the training data of size small. Furthermore, the disadvantages in the capabilities of computation in those days leads to the efficient way of deep FNN. In order to overcome these computational complexities, GPU Graphics Processing Units is developed and specifically accelerates the hardware performance. DL model have facilitated advancements in terms of effective algorithms of deep neural network includes,

- Using Activation function as ReLU (Rectified Linear Units)[31]
- Introduction of dropout layer[32]
- Assigning network weight by means of Random Initialization [33]
- By using residual neural learning, to address the reduction of training accuracy [34]
- By using Enhanced LSTM, to overcome vanishing and exploding gradient decent problems [35][36].

Deep Neural Network is otherwise known as multilayer neural network. It comprises of i) An Input Layer that is features and that depends on model features, ii) Numerous Hidden Layer that depends on model performance and iii) An Output Layer. Input feature( $x_1, x_2, \dots, x_n$ ) that multiplied to the corresponding weight( $w_1, w_2, \dots, w_n$ ) in order calculate its overall features ie. ( $x_1 w_1 + x_2 w_2 + x_3 w_3, \dots, x_n w_n$ ) and bias is like preference and its like some small weight is add at the end of the summation. For instance like  $(x_1 w_1 + x_2 w_2 + x_3 w_3, \dots, x_n w_n) + b$ . In such way it derives its overall forward propagation. **Figure 5** shows the multilayer neural network or deep neural network. Activation function is a function in which it describes the functionality of neuron.



**Figure 8:** Deep Neural Network Architecture[23]

In such a way it activate that particular neurons performance, in order to the functionality of the neuron. Numerous activation function are used in order to get the output like Sigmoid, ReLu, tanh etc. That how, forward propagation performs in order to calculate the output. If the

output is not satisfied, back propagation is employed in order to find the loss function and update the weight to pertain the output.

In a broad classification, DL Model is classified into 3 main categories, i) Generative ii) Discriminative, and iii) Hybrid Models. Generative Models are used to provide Supervised Learning Model. Generative Model are utilized for Unsupervised Learning Model. Hybrid Model comprises of both Generative and Discriminative Models. And the summary of various DL Models is summarized in **Table 4** as follow:

<b>Input Data Type</b>	<b>Learning Model</b>	<b>Category</b>	<b>Characteristics</b>	<b>Models used</b>	<b>IoT Application</b>
RAW	Unsupervised	Generative	<ol style="list-style-type: none"> <li>1. It is suitable of extraction of features and dimensionality reduction.</li> <li>2. Input and Output Unit have same.</li> <li>3. The obtained output is re-construct the input data.</li> </ol>	MNN	<ol style="list-style-type: none"> <li>1. To diagnosis the machinery fault.</li> <li>2. Recognition of Emotion.</li> </ol>
Time series and Serial	Supervised	Discriminative	<ol style="list-style-type: none"> <li>1. Through internal memory, it processes the data sequences.</li> <li>2. By means of time dependent data is used in IoT application.</li> </ol>	RNN	<ol style="list-style-type: none"> <li>1. To identify the pattern's movement.</li> <li>2. Detection of Behavior</li> </ol>
Various	Semi-	Hybrid	<ol style="list-style-type: none"> <li>1. It composed 3</li> </ol>	Ladder Net	<ol style="list-style-type: none"> <li>1. Recognition</li> </ol>

	Supervised		networks: 2 Encoders and 1 Decoder.  2. It is suitable only for inconsistent Data.		of Facial Activity.  2. Authentication
Various	Semi-Supervised	Hybrid	1. It composed 2 networks: Discriminator and generator.  2. It is suitable only for inconsistent Data.	GAN	1. Path-finding and Localization  2. To Transform Image to text
Various	Supervised and Unsupervised	Generative	1. It is fit for Classification, Dimensionality Reduction and Feature Extraction.	RBM	1. To predict the consumption of Energy.
Various	Supervised and Unsupervised	Generative	1. It is perfect for systematic feature selection.  2. Training a Layer by Layer in terms of Greedy Training	DBN	1. Classification to Detection of fault occurrences.  2. To identify the security threat.
Various	Semi-supervised	Generative	1. It suitable for labeled data scarcity.  2. Auto-encoders to pertain the class.	VAE	1. Detection of Intrusion  2. Detection of Failure.
2-	Supervised	Discriminat	Highest computation	CNN	Detection of Plant



dimensional (audio, image etc.)		ive	part is taken by Convolution layer.  Comparatively less connection required.  Vast Training dataset is required in order to get visual tasks.		Disease.  Detection of plant Disease.
Dependent of long time data, Time Series and Serial	Supervised	Discriminative	1. Performance is good, if the data for long time.  2. Gates are protected in order to access the memory.	LSTM	1. Recognition of Human Activity.  2. Prediction of Mobility rate.

**Table 3:** Various DL model used IOT application with their characteristics along with, learning model and categories.

**Conclusion:**

In this comprehensive survey work, various application of IoT along with AI, ML, DL approaches and its application are discussed. It explores some of the diversified areas where IoT plays a vital role by adopting various AI, ML and DL approaches. Additionally, some of the related surveys have also been discussed along with deep description based on the problems involved in AI, ML and DL and gives solution for those problems. As a result, we conclude that, by using AI, ML and DL for Iot, its result been very efficient on the basis of automation, monitoring and diagnosis and also achieved tremendous growth in real time application.

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