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A Framework for Ontology Based Semantic Search System in Ayurvedic Medicine

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ABSTRACT

India is known for its traditional medicinal system such as Ayurveda, Yoga, Unani, Siddha and Homeopathy. Ayurveda plays a significant role in curing the diseases without any side effects. Medicinal plants or herbs are considered as a major resource in meeting the need of people health care. Information about this medicinal knowledge must be preserved and digitized. There have been a massive number of publications and large number of articles on ayurvedic research in the form of unstructured textual data. Text mining approach is used to provide the solution to handle such voluminous of unstructured data. With the exponential growth of text based data, navigating the relevant information needed is the challenging task. Semantic understanding of document content formsthe vital requirement for ensuring the quality of content retrieval. However, the current approaches are finding variation in textual classification in bringing the classification accuracy which may fail to understand the data during classification. Hence, an efficient model is required to search, classify and retrieve the most relevant data. The main objective of this research isto develop an effective and efficient framework and algorithm to search and retrieve the most relevant facts by including the application of ontology-based text mining approach. The current status of research is analyzed and reviewed in the area of semantic web retrieval, ontology-based approaches and various classification technique for building the framework. Text mining with the special emphasis on understanding the semantic meaning of content is achieved by using domain ontology called medicinal plant ontology construction. The challenges in finding the semantically related content for the given query are achieved through semantic web and ontology which enriched the data on web for structured representation thereby providing the strong semantics in knowledge representation. The methodology of information extraction is implemented by using medicinal plant ontology with semantic knowledge representation, an algorithm called OCEC (Ontology based Concept Extraction and Classification) was developed where each term is described semantically by mapping the terms and its related terms in the medicinal plant ontology. The web language called Web Ontology Language (OWL) is used for knowledge representation and is considered as richer semantic description language for describing unstructured and semi-structured content on the web thereby extracting the exact and relevant data and to offer a strong semantic search. To evaluate the performance of the proposed method, less relevant and most relevant documents were collected from online sources and digital libraries. Comparative study has been performed with various classification techniques. The experimental results show that the proposed method out performed. To further prove the efficiency of the model, experiments were conducted by giving different queries and the results are compared with other existing methods. The results show that the content retrieved by the proposed model improves precision and recall results.

Keywords : Ayurveda, Ontology, Semantic Web, Traditional Medicine, Web Ontology Language.

INTRODUCTION

In this digital world, the quantity of information produced everywhere leads to a data-intensive world.

People in the world are connected by an internet which enables sharing of data with wide variety of interaction and offers global communication. Data is generated by every people and in almost all businesses and processes. This textual data is ubiquitous and growing rapidly. The major problem is that, data is available as unstructured messy data. So, making sense out of raw data and utilizing it for various applications is a challenging task of text mining process. Due to this, there was a need to design and develop methods and techniques which are used effectively to process a range of text based applications. In near past, the problem of text mining has increased much attention to process the huge amount of textual data and lot of research study was done to discover the useful knowledge from this voluminous content [1].

Ayurveda has gained much of significance in the last two decades. Many people are practicing this medicine in many parts of the world [2]. Ayurveda medicine can be followed and adapted in different countries with suitable modifications by considering its tradition, culture and constitutional profile of their population. Medicinal plants or herbs are considered as a major resource in meeting the need of people health care.

A recent study pointed out that there are more than 13,000 plants has been examined. There are various medicinal plants possess high medical values [3]. The following table 1 shows some of the medicinal plants along with their usage.

Table 1 : Some of the Medicinal Plants and its Use

Botanical Name	Common Name	Parts Used	Medicinal Uses
Swertia chirayita	Chirata	Whole plant	Skin disease, burning sensation, fever.
Ocimum sanclum	Tulsi	Leaves, root	Cough, cold, bronchitis
Grit kumari	Aloe vera	Leaves	Laxative, wound healing, skin burns and care, ulcer.
Azadirachta indica	Neem	Rhizome	Sedative, analgesic, epilepsy, hypertensive.
Saraca assoca	Ashok	Bark, flower	Menstrual pain, uterine, disorder, diabetes.
Commiphora wightii	Guggul	Gum rasine	Arthritis, paralysis, laxative.
Piper longum	long pepper	Fruit, root	Appetizer, enlarged spleen, bronchitis, cold, antidote.
Asparagus racemosus	Shatavari	Tuber, root	Enhance lactation, general weakness, fatigue, cough.
Terminalia chebula	Haridra	Seed	Wound, ulcers, leprosy, inflammation, cough.

PROBLEM DEFINITION

As pointed earlier, Ayurveda plays a major role in human life and it use herbs for treatment of diseases without causing any side effects. Information about this medicinal knowledge must be preserved because it exists from Vedic period. Number of publications and articles in ayurveda are published in the form of documents [4]. Hence, an efficient model is required to search and know the most relevant facts from these documents. In existing search engine, the searching is based on the keyword, it produces the result which may or may not be relevant to the user. For example, if the user gives the query as “Apple”. The results seem to be generic. It shows the contents about the fruit apple and also the apple product like I-phone, I-Pod, etc. The user intention may not be understood semantically. The main limitations of the web search today are,

The searching results have high recall, low precision.
Results are sensitive towards vocabulary.
Results are single web pages.
Contents on the web are not structured.

Hence, a technique is required to improve the efficiency of the model in order to search and retrieve the most relevant data. For understanding the information and to dig the useful and relevant ayurvedic content there should be a proper representation of knowledge. The main drawback of search engine today is that it does not understand the meaning of web content and it is not machined accessible. Although there are many tools available for retrieving text, the capabilities of such tool are still considered to be limited for retrieving the relevant information by understanding the content. It is quite difficult for machines to distinguish the meaning of "bank" when used in different context at different places. Recent days, Ontology is offering an explicit specification of a shared knowledge and conceptualization. Now, it becomes a modeling technique to represent information. Ontology typically consists of concepts, properties, instances and axioms. Different languages such as RDFS and OWL were utilized to represent ontology in a machine-readable form. Ontology ensures strong semantics in knowledge representation for many applications. Ontology and semantic web plays a vital role in deep understanding of information on the web. Ontology forms the backbone of the semantic web. It is considered to be important on the semantic clarity of concepts and entities which greatly improves and enhance the information analysis, sharing, retrieval and reuse [5] Therefore semantic web is used as an alternative approach for representing the web content which is easily machine accessible by using intelligent techniques.

EXISTING SYSTEM

[6] presented an application called semantic search. This was developed to overcome the drawbacks of existing search and designed to improve the traditional search. They discussed different supporting technologies to search for the data which is semantically related. [7] presented a new semantic search engine framework. It provides effective search by solving the issues on querying the semantic web. [8] gave an overview about semantic search engine. They developed semantic search engine based on ontology. Domain ontology for tourism was built with tourism information which makes use of synonym dataset by using WordNet to understand the meaning of the input queries in the searchable interface. [9] proposed an efficient semantic search engine framework. They developed engine by using new semantic ranking algorithm which operates over a sorting RDF triples. The framework typically includes four phases such as crawling, indexing, ranking and retrieval. It also included with enhanced crawling algorithm which crawls the relevant content from the web with minimal overhead. [10] Proposed an approach to enhance the performance of the information retrieval process from the digital library by using ontology. The retrieval system is based on ontology which uses ontology based annotations to retrieve the relevant result and recommend related topics. They evaluated and reviewed the performance of the ontology based search by comparing with keyword search. [11] proposed ontology based semantic search engine. It includes two types of search such as keyword-based search and a semantics-based search. This search engine works with different technologies such as domain ontology and RDF for the representation of data. They compared their search engine results by submitting queries to the system and measured their performance and efficiency by submitting the same set of queries to other existing search engine like Kngine, Wolfram Alpha and Google. The limitations of the existing work includes the following 1.There was not much work focused in the domain - Ayurveda for retrieving the relevant information related to this area of medicine. 2. Construction of medicinal plant ontology plays a significant role in understanding the concepts and its related concepts in that particular domain. Most of the researchers used the existing ontology which may fail to understand their point of focus and indent of knowledge discovery. 3. Text classification is considered as one of the main tasks included in text mining process for information retrieval. It forms the supervised machine learning process for document classification. Semantic understanding of document content forms the vital

requirement for ensuring the quality of content retrieval. However, the current approaches are finding variation in textual classification in bringing the classification accuracy which may fail to understand the data during classification.

PROPOSED METHOD

In order to define an effective model to retrieve the most relevant content from ayurvedic document and to provide semantic description to the document by mapping the concept from medicinal plant ontology and to improve the performance of the classification task, ontology based semantic retrieval system is proposed and viewed as layer. The architecture of proposed framework is shown in "Fig. 1".

It consists of five phases,

1. Data collection
2. Pre-processing and classification
3. Ontology development and reasoning
4. Knowledge representation
5. User search query

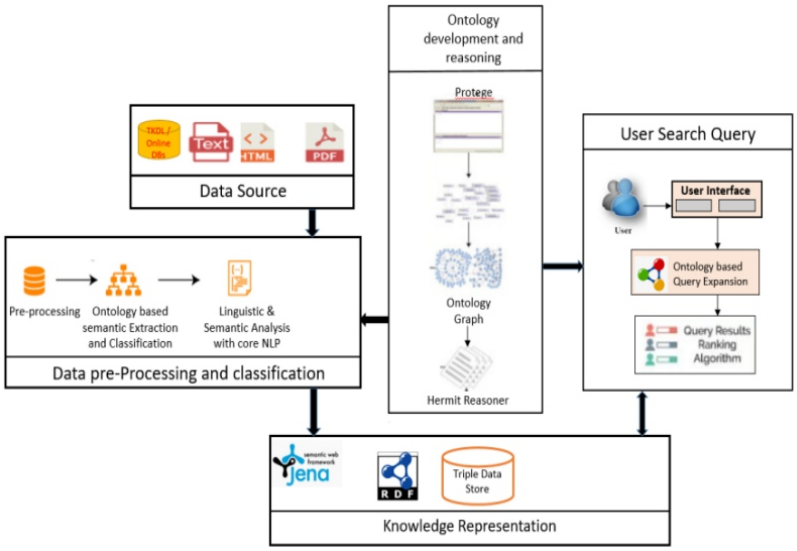

Figure 1. Architecture of Proposed System

The Indian herb based documents were collected from the TKDL, PubMed, NCBI and other online digital repositories. Pre-processing is done to transform the text into something an algorithm can digest is a complicated process. It forms the important task before classification, as this process is used to remove unwanted information from the document and to reduce the document size and appropriate content will be considered for the processing [12]. The pre-processing steps such as Tokenization, POS tagging, stop word removal, Stemming are done on the collected documents. Domain ontology plays a vital role in integrating the semantic features with the information retrieval. This kind of integration is needed to extract synonyms, polysemy words that are the term relevant to the important terms. Domain Ontology called medicinal plant ontology was constructed [13]. Based on this, the ontology based classification algorithm is proposed which forms the basis for semantic data classification. We used algorithm called "Ontology based Concept Extraction and Classification (OCEC)" for learning the semantic aspect of the classification using medicinal plant ontology and for classification of every new document [14]. To represent the document and for extracting the featuresTF-IDF weighting was used.

Before identifying the weighting, it includes the semantic description of documents. This helps in identifying the terms as concepts in the document. Thus the documents are represented as vector of concepts. Each term is described semantically by mapping the terms and its related terms in the medicinal plant ontology. Thus it involves the process of checking whether the concept is present in medicinal plant ontology. Now the concept is extracted and concept weighting is calculated for finding how important and relevant the document is. Classification process is carried out by using kNN classifier to assign documents to predefined classes. Hence the ontology based extraction and classification system able to understand the data during retrieval process, thereby enhancing the quality and consistency of the overall classification process.

RESULTS AND DISCUSSIONS

Different search techniques like keyword-based search and ontology-based Search were compared with the proposed method. Keyword-based search algorithm works based on syntactic search that contains deficiencies. However, the algorithm does not support for semantic information retrieval effectively. It concentrates on enriching the information retrieval semantic annotation but the input herb query are not explicitly available in the text. Therefore the method are unable to display the results. It also lacks in deep retrieval inference in library to extract the content. For example, searching for herb "Triphala" and "Terminalia bellirica" often gives different information although both queries are semantically related. Even though, the method tries to focuses on semantics model and semantic search, it does not address knowledge representation system. Ontology-based search algorithm by introducing the method which works with the integration of semantic search and ontology based reasoning. Where, semantic web search are widely used in digital libraries for information retrieval systems. This method work to expresses that how information retrieval system can be improved. Here, the method displays the result in ontology class representation and as well as keyword-based information retrieval systems. It is used for prioritizing disease and symptoms complexes for an herb interest and the algorithm relies on prior phenotypic information, and able to find herb similarity based on disease symptoms. The method only retrieved the information which is linked with the ontology instance. It is unable to recognize synonyms of keywords. However, it does not consider the herb knowledge representation for mapping the relationship between herbs and disease. Proposed method finalizes the semantic evaluation process through utilization of system relevance to the users by mapping with medicinal plant ontology. In detail, each document is displayed by two similarity values. The proposed method applies the ranking of retrieved content based on distance of the document and the query where the lowest distance indicates that retrieved content has most relevant result. The ranking function states that optimum retrieved result is given if the retrieved herb information resources are prioritized according to their probability that resource is relevant to the user query. The results proved that, the proposed system bring most promising and prominent output compared with other different kinds of search as shown in table 2. From "Fig 2", it indicates that, number of retrieved contents by the proposed method was more relevant and the number of relevant contents retrieved for the given queries was high when compared with other existing techniques.

Table 2 : Comparison of Recall and Precision Value on Various Search Techniques

S.No	Queries	keyword-based search		ontology-based search		proposed system	
		Recall	***Precision***	***Recall***	***Precision***	***Recall***	***Precision***
1	Indian gooseberry	0.92	0.82	0.82	0.79	1	0.85
2	Arjuna	0.45	0.55	0.9	0.42	0.97	0.75
3	winter cherry	0.29	0.29	0.7	0.62	0.95	0.87
4	Fenugreek	0.87	0.42	0.94	0.44	1	0.75
5	Lemon Grass	0.94	0.1	1	0.65	1	0.8
6	Neem	0.66	0.29	0.83	0.66	0.99	0.79
7	Tulsi	0.89	0.38	0.78	0.73	0.92	0.88
8	Caraway	0.59	0.26	0.79	0.68	0.83	0.79
9	Clove	0.95	0.78	0.95	0.47	1	0.65
10	Ginger	0.4	0.1	0.89	0.67	0.9	0.97
11	Garlic	0.9	0.23	0.93	0.95	0.75	0.99
12	Lemon Balm	0.5	0.45	0.89	0.76	0.95	0.59
13	Mints	0.19	0.13	0.89	0.64	0.79	0.47
14	Cinnamon	0.85	0.24	0.5	0.63	0.95	0.73
15	Rosemary	0.49	0.29	0.9	0.82	0.94	0.83
16	Ashwagandha	0.78	0.14	0.92	0.56	1	0.83
17	Fennel	0.85	0.69	0.86	0.7	0.95	0.85
18	turmeric	0.95	0.5	0.83	0.93	1	1
19	Triphala	0.83	0.57	0.83	0.82	0.95	0.93
20	Asafoetida	0.93	0.5	0.95	0.6	0.79	1
Average Recall & Precision		**0.711**	**0.386**	**0.855**	**0.677**	**0.931**	**0.816**

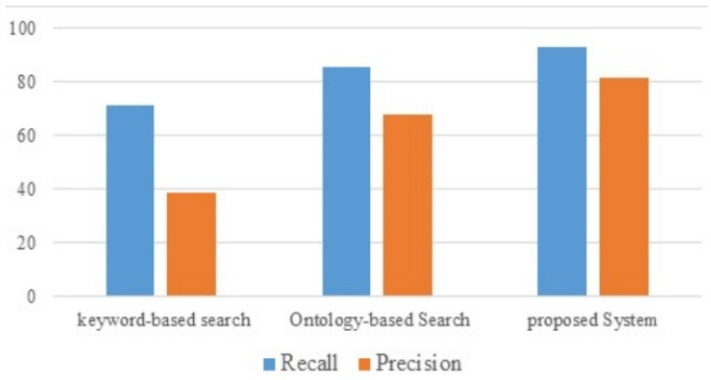

Figure 2. Comparative Analysis of Different Search Techniques with Proposed Method

CONCLUSION

An effective and efficient framework is proposed to search and retrieve the most relevant facts by including the application of ontology based text mining approach. Medicinal plant ontology is constructed which greatly helps in understanding the knowledge in that domain. This knowledge is stored in the OWL which greatly results in strong semantic representation of that knowledge. New method of classification is followed to automatically identify the herb related information from the ayurvedic biomedical literature. The documents are semantically described which enhance the classification technique thereby producing the most appropriate results. To provide human like understanding of system, deep learning algorithm may be applied to further improve the performance and accuracy. Many open source latest tools like orange, KNIME can also be used to apply different algorithm with different perspective. A maximum number of text mining measures can be implemented and graphical visualization can be enhanced in a better way. Current technology such as cloud and

mobile computing are used increasingly for a wide variety of applications. These technologies bring a new set of challenges like security and privacy. Text mining techniques can be extended to profit from the positives and avoid or workaround the drawback of these systems.

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Hybrid Spectrum Sensing Techniques in 5G Cognitive Radio Networks in Soft Computing: A Review

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ABSTRACT

This paper describes an updated and efficient method for Hybrid spectrum sensing in cognitive radio (CR) system utilizing soft computing paradigms. The suggested soft computing approach utilizes an artificial neural network and for learning and decision making as a solution to the problems when a new product is subjected to the CR framework, developed the ability for unlicensed cognitive users to access radio frequencies through a spectrum hole and understand its implications through mechanisms spectrum sensing. The suggested soft computing approach could then be referred to as the Neuro technique. The need for higher bandwidth is important with the rise in the number of communication devices. Usage of cognitive radio for the fifth generation 5G communication network of the next generation Consider the fact that CR technology will efficiently optimize the use of much of the unused communication spectrum bands for the future 5G of wireless network and beyond.

Keywords : 5G Cognitive Radio (CR), ANN technique, Hybrid spectrum sensing.

INTRODUCTION

Spectrum services are becoming increasingly limited with the exponential development of wireless networking technology and the introduction of 5 G large multiple-input multiple-output (MIMO) systems[1]. The total use of spectrum varies from 7 to 34 percent, as per the spectrum occupancy campaign in 2016, indicating substantial under-use of spectrum resources[2]. For the spectrum band's effective utilization and opportunistic use, the spectrum distribution has to be complicated. Cognitive Radio (DSA/CR) is intended to be a promising alternative to reduce this emerging controversy between the competition for spectrum and the under-use spectrum[3]. CR schemes seek to improve the effectiveness of the use of spectrum by enabling unlicensed or secondary users (SUs) to enter momentarily unlicensed or primary users (PUs) licensed spectrum bands in a non-interfering manner[4]. Precisely, CR takes advantage of radio spectrum components that are not populated in certain specific positions at certain specific times and transfer its activity to these components called spectrum holes or white spaces for opportunistic access[5]. The literature has indicated a variety of various spectrum sensing schemes[6]. Several spectrum sensing techniques have been explained in [7, 8], particularly matched philter identification, adaptive spectrum sensing, and cyclostationary based sensing. Energy detection[9, 10], which contrasts the obtained signal energy with a predefined threshold and decides the PU state, either busy or idle, is one of the most basic and commonly popular non-parametric sensing schemes. It is easy to incorporate energy detection, but it is susceptible to signal and noise uncertainty[11, 12]

LITERATURE SURVEY

In particular, by following the characteristics of Cus without disrupting the behaviors of PUs, the

efficiency of the wireless communication device can be increased. The researchers have suggested numerous spectrum control tasks, except spectrum detection, spectrum detection, and spectrum determination for the CUs. Various techniques such as energy detection, matched philters, cyclostationarities, and wavelet detections have been widely used in spectrum sensing to recognize the radio frequency channel status.

The next generation's network connection will be listed as the Fifth Generation (5 G) and is planned to be commercialized in the next few years[13,14]. With a minimum of 1 ms latency and greater usage power and battery life, the estimated data rate for the 5 G network is about 100 Gbps[15,16]. Different future options include the use of the millimeter-wave frequency band, are in the process to achieve the required level of service (QoS)

Spectrum sensing is among the most complicated CR systems tasks because it needs high precision and high efficiency for dynamic spectrum entry.

Higher detection possibility ensures more excellent safety of primary users (Pus), and lower possibility of false alarm assures more probability of secondary users (SUs) using thechannel. For all the sensing algorithms, a false alarm probability of 10 percent and a detection probability of 90 percent were seen as the aim specifications.

Venkatesan et al.[19], who suggested studies on artificial neural networks and optimized real radio output under a cognitive radio system, implemented a learning scheme. He provided specific examples, including industrial virtual hardware systems that are not widely accessible to the public and simulated hardware/software goods that are mobilized to access output work, and the performance of suitable prototypes to be used for the proper structure of the neural network.

A few studies, including the Multilayer Perception and Secret Markov Model, have preferred to use neural network models as they do not require established expertise to use numerical networks. It was suggested by Tumuluru et al.[21], who showed critical benefits of using a channel stage predictor for spectrum sensing activities, which would essentially save the SU's output from sensing energy. Researchers have analyzed channel status prediction systems and their potential reliabilities for qualitative performance measurement.

To use better particle swarm optimization (PSO) techniques, Tang developed a method to solve non-convex optimization problems. Via integrated simulated annealing (SA), he suggested methods to address the main problems of individual components and PSOs to form a PSOSA algorithm. His algorithm's results demonstrate that the solution obtained was considerably more effective than current methods.

Similarly, in the current study, the authors suggested a spectrum of an intelligent radio that conducts vision, comprehension, and analysis spatially. Therefore, these concepts have also been extended to CR networks. The Naive Bayesian Classifier (NBC) dependent multi-class spectrum sensing detection was suggested. At the same time, the authors proposed a random forest classifier-based solution to eliminate unlicensed user interaction with licensed users in the CR network, thus significantly increasing network throughput.

The authors suggested a sensing scheme that uses energy and cyclostationary characteristics to train the spectrum sensing neural network. We used energy and Zhang statistics as a training function for ANN in our previous work[22]. The multi-slot spectrum projection based on ANN and the selection of adaptive mode in the full-duplex CR network were suggested in [10]. In recent work, the systematic analysis of machine learning-based spectrum sensing in CR can be identified[24].

Several researchers have discussed different simulation algorithms[24-27] and have researched various artificial neural network tools, interpretation, and modeling[28-19].

Encouragement

The collection of hyperparameters in an ANN for CR network is extensively analyzed and studied to achieve a better ANN classification performance, leading to higher detection efficiency at low SNR. There is a systematic analysis of the effect of the lower and higher SNR regime on ANN results. Research studies indicate ANN's superior efficiency across lower and higher SNR regimes relative to current CED and IED algorithms. ANN's tuned hyperparameters such as activation function, optimization algorithms, and learning rate are validated based on observational data sets of different radio technology. Besides, the effect of the number of epochs for which the neural network is trained on the loss function is explored for various optimizers. Current outcomes show that the proposed ANN architecture for spectrum sensing outperforms CED and IED algorithms by identifying the best hyperparameters.

HYBRIDE SPECTRUM SENSING

Energy Detection

There are several issues with low SNR that limit the efficiency of the energy detection method [32], such as the method of energy detection.

Noise, mentoring, and channel fading ambiguity, and the significant difficulty in this strategy is quantifying the noise.

In the classic form, we see that a static threshold is used, but as we realize that the detection threshold is used, the threshold depends on the ambient noise. In this work, we suggest a complicated threshold to maximize the noise Sensing probability.[33]

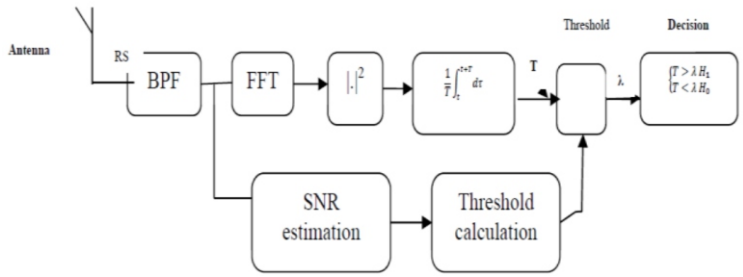

Fig 1: Energy Detection Model

The execution was performed in the Matlab software. The energy detector model is split.

In two bits. In the first part, at 100, the primary consumer emits an FM signal. Simulating a real one In communication, we add Gaussian noise to the signal.

We notice the secondary consumer in the second section, which

This includes an algorithm for energy detection to indicate the presence or absence of a primary signal.[34]

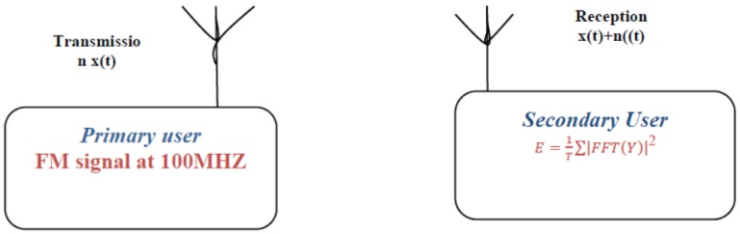

Fig 2: A simulation model

Match Filter Spectrum Detection

A matched philter (MF) is a linear philter configured for a given input signal to optimize the output signal to noise ratio. Matched philter recognition is implemented because secondary users have advanced experience of the primary consumer signal. The function of the matched philter is analogous to a similarity in which the unidentified signal is transformed to the philter whose frequency response is the variant of the transmitted signal mirror and time-shifted Matched philter detection operation is expressed as:

$$Y[n] = \sum_{k=-\infty}^{\infty} h[n-k]x[k] \quad (1)$$

Where 'x' is the unknown signal vector and is combined with 'h', the matched filter's impulse response is matched to the reference signal to maximize the SNR. Monitoring using the matched filter is useful only in cases where cognitive users are informed by primary users[35]

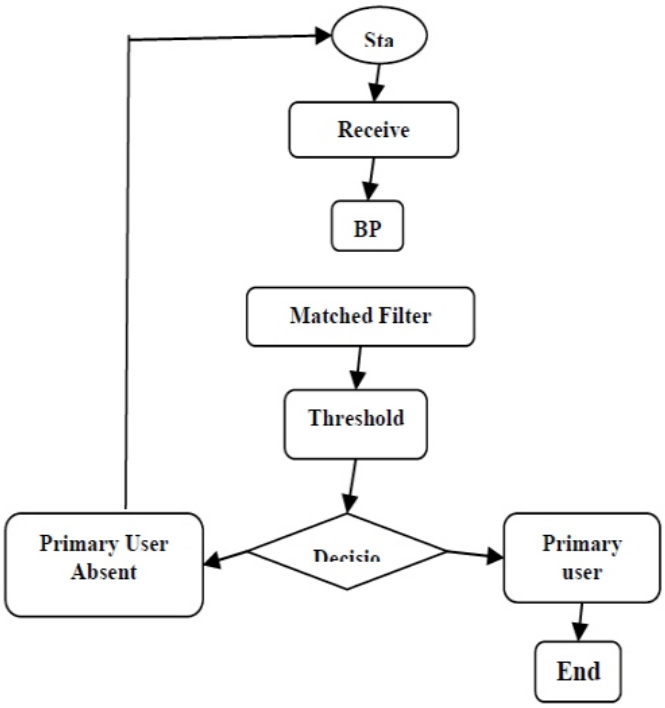

Fig 3: flow diagram of Matched filter Detection

Cyclostationary Feature Spectrum Detection

The To assess the involvement of primary users (PU), it takes advantage of the rate of change in the provided primary signal. In sinusoidal carriers, pulse trains, distributed code, hopping sequences, or cyclic prefixes of the primary signals, the periodicity is typically embedded. These cyclostationary signals display repetitive statistical and spectral similarity properties that are not observed in stationary noise and interference due to their periodicity [36]. Cyclostationary function detection is also resistant to noise uncertainties and performs better in low SNR regions than energy detection. Although it needs a priori awareness of the parameters of the signal, the identification of cyclostationary features will differentiate CR outputs from different types of PU signals. In cooperative sensing, this reduces the synchronization requirement of energy detection. Besides, during cooperative sensing and thereby enhance the overall CR throughput, CR users might not be needed to remain silent. Due to its high computational sophistication and long sensing time, this approach has its deficiencies. This method of detection is less common than spectrum sensing in cooperative sensing due to these problems [37].

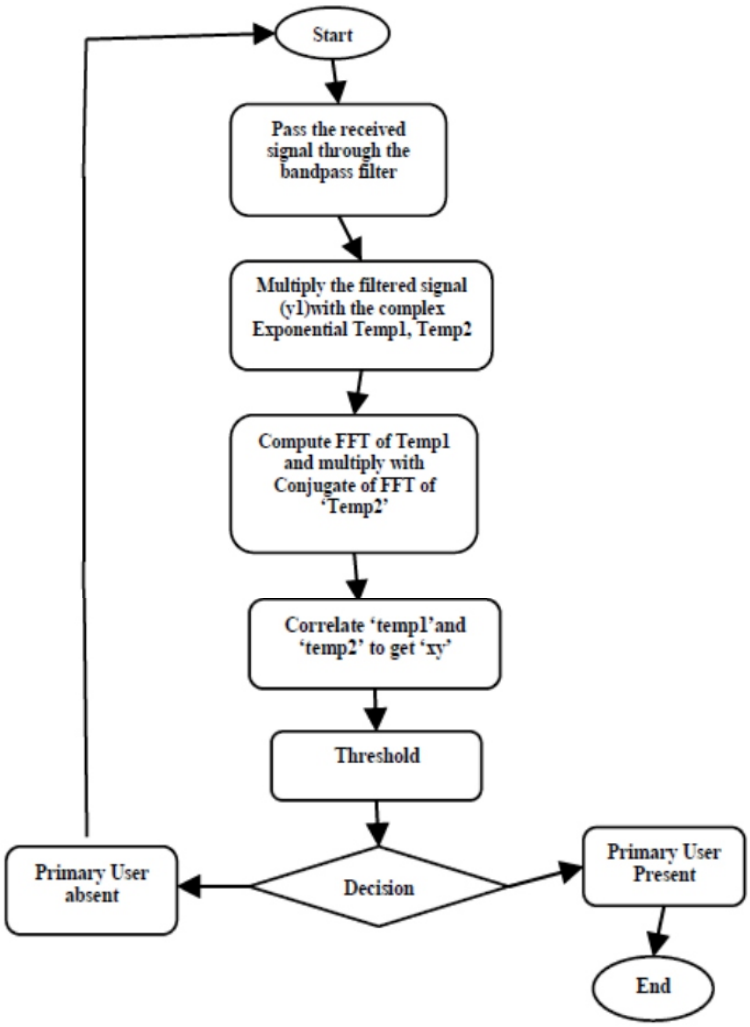

Fig 4: Flow diagram of Cyclostationary feature Detection.

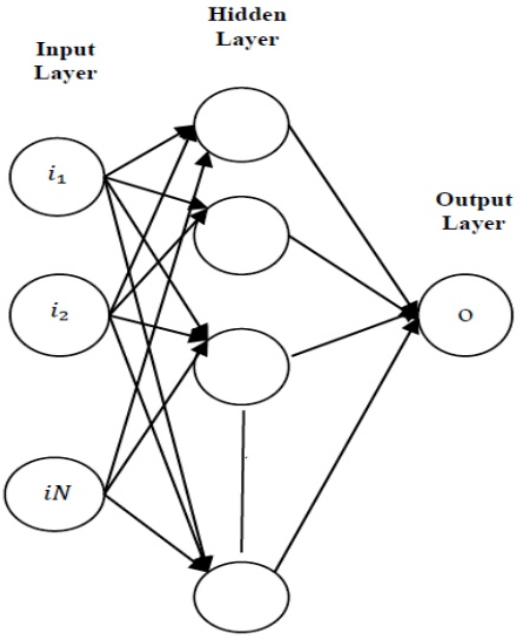

Fig 3: : ANN structure

ARTIFICIAL NEURAL NETWORK

Model of the Framework

A standard neural network architecture with one hidden layer and one single output is shown in Fig. 5. We presume that in a CR network, an SU detects only a single PU channel activity signal using the spectrum sensing algorithm consequently proposed. Here the SU is expected to regularly sense the PU's channel to decide

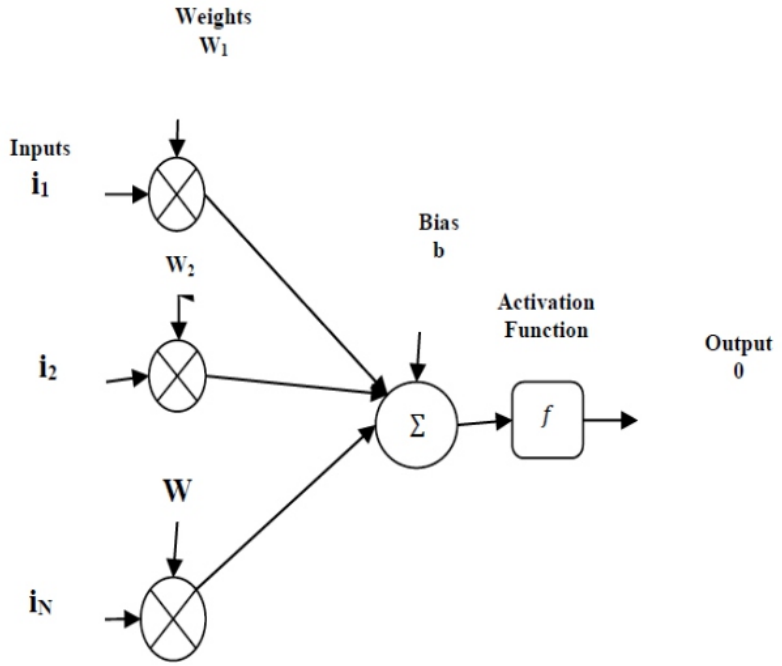

Fig 4: Hidden layer neuron structure

Whereas the hypothesis $H_{i.1}$ suggests that the PU is current and the probability of spectrum is inaccessible at the SU stamp. Based on the observations captured, *y1,y2,.....yi,.....yk,.....,yK,* The primary aim is to predict if the channel will be idle or busy in the next 1st timestamp, i.e.*(K+1) th.* The goal is to measure, mathematically, the following probability distribution:

$$Pr\left(H_{k+1,j} | y^1, y^2, \ldots, y_k\right), \quad (2)$$

Where Remember that the null hypothesis is suggested by, while suggests the alternative hypothesis. To compute this probability, there are various mathematical models. After all, given the extraordinary potential to suit complex non-linear functions, an ANN-based method was carried out in this work.
Further, we extract four characteristics of the received signal as defined in Sect. 3, represented as X, to be supplied to the ANN as data. The neural network is then used to learn the mapping of

$$Pr\left(H_{k+1,j} | X_k\right), j \in \{0,1\} \quad (3)$$

Hyperparameter ANN-based Hybride Spectrum Sensing Scheme

The far more significant aspect of neural networks is that they are excellent in understanding non-linear functional mapping between input and output and thus respond to PU signals' non-linear features. A back amplification neuralnetwork (BPNN) is used in the suggested sensing system. Our proposed method is

aimed at determining/classifying whether the PU channel is active or idle. We use a supervised learning environment in this article, where the classifier is trained with characteristics and associated marks. The ANN mainly integrates classical statistics of energy detection and probability ratio as its characteristics. For situations where the channel is idle and busy, the labels in this classifier are 0 and 1, respectively. The energy value *E* is given by denoting the discrete version of the obtained signal as *yi* aS :

$$E = \sum_{i=1}^{N} |y_i|^2 \quad (4)$$

The Zhang Statistic Z*c*Z*c* is given as:

$$Z_c = \sum_{i=1}^{N} [log \left\{ \frac{F_0(y_i)^{-1} - 1}{\frac{N - \frac{1}{2}}{i - \frac{3}{4}} - 1} \right\}]^2 \quad (5)$$

The established sampling distribution (CDF) of noise is where *N* is the sample size and is the first step is to collect data. The first function is the signal energy, denoted as *x1 (1)* where *l* denotes the lth training sample. The second function is the preceding sensing event's energy value, denoted as x1(l). Also, we consider this function to prevent a sudden decrease in energy values caused by minor errors caused by experimental configuration leading to miss-classification. Likewise, the third and fourth characteristics are respectively denoted by the Zhang statistics of the present and previous sensing cases.

Similarly, the labels for the training sample are denoted by l. Here, l is the function vector index, separate from *k,* which is the number of the row index Uh Mode. In terms of machine learning, validation is a significant step. There may be a situation in which the classifier recalls all the training data set characteristics and may work amazingly on the training data set, but then fails when practically implemented introduced to real-life structures. One patent explanation for such cases is that the ANN has remembered and did not read or appreciate the training data[40]. This problem is known as data over-fitting. Data sets are commonly split into three separate sets to avoid this issue: preparation, validation, and verification. The validation data set uses all the models that have been learned to test the algorithm's output using the training data set. Also, to verify how many times the classifier incorrectly predicts the names, an indicator function is used. Also, the model is chosen which achieves the lowest value of the indicator function

Development with ANN

The primary aim of ANN development is to mitigate the value feature described in (11). There are two steps designed to train each ANN model sequentially, namely forward amplification and backward amplification, which are described below:

• Forwards Amplification

The function vector is provided as an input to the ANN, and specific weight values are allocated to each neuron. The neuron weights are multiplied with extracted features in the forward pass and applied to a bias value, which is ultimately passed to hidden layers as an input. For an ANN with nHhidden layers, mathematically,

$$net_j = \sum_{i=1}^{p} x_i w_{ji} + w_{j0} \quad (6)$$

Where *f* si the value of the i*th* function, is the j*th* hidden layer's weight, w*j0* is the bias value, and is the hidden layer's net activation. You can obtain the output of the hidden layer of *jth* by:

$$y_j = f(net_j) \tag{7}$$

where represents the activation function. Equally, for the output layer of the ANN;
we measure the net activation and output:

$$net_k = \sum_{j=1}^{n_H} y_j w_{kj} + w_{kC} \tag{8}$$

$$z_k = f(net_k) \tag{9}$$

Here, the activation function maps input R →[0,1] . That's one of the hyperparameters that can be tailored for better performance to be obtained. The best activation function can be used for checking the ANN model after analyzing different activation activation functions on actual-world signals.

• Back Amplification

This measures the expense parameter gradient. The error in the output to the input neurons is then determined using the separation following equation as follow:

$$\frac{\partial J}{\partial w_{ji}} = \frac{\partial J}{\partial_{zk}} \frac{\partial_{zk}}{\partial net_k} \frac{\partial net_k}{\partial y_j} \frac{\partial y_j}{\partial net_j} \frac{\partial net_j}{\partial w_{ji}} \tag{10}$$

$$\frac{\partial J}{\partial w_{ji}} = \frac{\partial J}{\partial_{zk}} \frac{\partial_{zk}}{\partial net_k} \frac{\partial net_k}{\partial y_j} \frac{\partial y_j}{\partial net_j} \frac{\partial net_j}{\partial w_{ji}} \tag{11}$$

By going in the maximum margin range, the neural network weights are modified using such gradients, reducing the objective functions. There are various assessment methods, such as Adam optimizer, to change the weights, momentum-based gradient descent, etc.
The different hyperparameters, the best of which are used after analyzing their output on different real-world signals in testing the ANN model

Methods of Simulation

The solution methods used to achieve higher accuracy with each radio technology are discussed in this section.
1. Stochastic gradient descent (SGD): This algorithm improves the value function j(w) parameters was:

$$w := w - \eta . \nabla wj \tag{12}$$

For those changes, the simulation time g remains unchanged. Often to prevent overheating the saturation stage, the back amplification for SGD is usually lower than batch gradient descent.
2. AdaGrad: This algorithm is a useful tool for successful learning rate adjustment[39]. Compared to having a similar training set with all the weights, it preserves the information gain per parameter. One of the disadvantages of AdaGrad is that the training error gets slightly lower as it gets closer to the target. Still, even after several tests, it can not achieve the very minimum.
3. Adam: It's possible to use this optimization technique rather than and after several variations, it gets

slightly smaller, so it does not meet the exact minimum classical SGD for filling gaps weight values regarding the training results. " Adaptive Moment Estimation " (ADAM)[43] is the term that comes. A focus on addressing is retained for each network weight (parameter) and adapted individually as testing unfolds, unlike the classical SGD that retains a single training set for all the weight changes. Adam knows the advantages of both AdaGrad and RMSProp (another optimization algorithm), including the use of regression periods of the first (mean) and second (uncensored variance).

The ADAM optimizer is used to achieve quicker optimization. Though, the highest performing compiler is subject to the data set that it is educated and checked on. In the case of spectrum sensing, Nesterov's rapid differential performing the skill, owing to its ability to acquire velocity and prevent dependence on other state space, yields minimal model loss.
The option of the activation function is yet another significant hyperparameter to be calibrated efficiently. For that, to evaluate the efficiency of the suggested ANN architecture, we include the following activation functions:
1. Activation feature of Sigmoid:

$$f(a) = \frac{1}{1+e^{-a}}, \tag{13}$$

2. Activation feature of ReLU:

$$f(a) = \max(0, a), \tag{14}$$

3. Activation feature of Tanh:

$$f(a) = \frac{e^{a}-e^{-a}}{e^{a}+e^{-a}}, \tag{15}$$

Sigmoid and Tanh are typically haven't used due to the neural network issues, which essentially reduces the accuracy rate. However, in spectrum sensing, because the network used is not large, all activation functions yield the same precision of the segment on numerical effects.

The validity of Data Captured
Although the randomness factor and its implications are difficult to remove from the empirical setup, the data collected was used to replicate the results of the CED and IED equations given in[41]. Furthermore, to guarantee the quality of the information set, the data collection and sensing validation were replicated numerous cycles for the proposed method, and the quality barely changed. These experiments were also taken to ensure no unusual or erroneous patterns that violated basic theoretical expectations (e.g. rise in the SNR and sample size N, increase in Pd).

Summary of various features
Taking into account various sets of functions, we evaluate the efficacy of the suggested architecture as follows:
(1) just present measurements of energy,
(2) only new samples of Zhang statistics,
(3) recent comparisons including both energy and Zhang statistics, and
(4) various state samples of both energy and Zhang statistics. More precisely, we test the performance of

how qualified ANN suits the information of standard error.

OUTCOMES

The suggested spectrum sensing scheme based on ANN was checked and analyzed on scientific evidence. Rather than using channels from just a single cognitive radio, we selected channels with different radio technologies. The average efficiency of single radio technology for multiple channels was considered quite equal. Therefore, four ANN architectures have been used, and particular radio technology is assigned, as mentioned earlier. The identification frequency Pd and the false alarm rate Pf are calculated, having received separate training and certification results for each radio technology. A single ANN may also be used to combine all radio technologies combined, but in doing so, as per [42], the intrinsic impact of technology reliance on Pd can be ignored. For each radio technology, a comparative evaluation of the project method with current CED and IED algorithms on collected data is made. The findings indicate that the suggested scheme outperforms.

ANN SCHEME REVIEW

The suggested ANN-based sensing system was evaluated as evident by including all radio technologies with various strengths of sample sizes and false alarm frequencies. Even the detection efficacy of the suggested scheme is comparable to CED and IED sensing schemes. SNR correlation with NBC in [32] and BPNN for the current proposal. In our case, the spectrum data is obtained through the configuration of the analytical testbed. However, we have created the data through the parameter values given in [32] for a fair comparison. We could see that our suggested methodology behaves very similarly with the NBC at low SNR regime relative to the BPNN scheme without hyperparameter. This is relative to the learned model without hyperparameter tuning; the suggested methodology learns faster whenever the hyperparameters are tuned.

CONCLUSIONS

A new hybrid spectrum sensing device in this paper implemented is already. The analysis has been checked utilizing an innovative proof of concept setup based on different radio technologies. The researchers acknowledged that for all regarded radio technology, the suggested scheme greatly surpasses traditional energy detection methods and other new methods of energy detection. One part of the potential work should be seen as reducing the learning time needed; the other can be considered as integrating various other related features to achieve greater consistency in results. Definitely, the larger the number of functions, the larger the computing efficiency; it is difficult to satisfy all of these things at the time.

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A Review on Artificial Intelligence – Assisted CCTA Imaging for CAD Diagnosis

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ABSTRACT

According to the statistics committee of the American Heart Association, Coronary Artery Disease (CAD) or myocardial ischemia is one of the most common Cardiovascular Diseases (CVD) that has high morbidity and mortality worldwide. Though Invasive Coronary Angiography (ICA) is recognized as the gold standard for the diagnosis of stenosis-related CAD owing to its ability to identify and classify stenoses precisely, it has severe complications and side effects. As a result, Image segmentation evaluation parameters and Automatic diagnosis have all benefited by using AI in non invasive technology known as CCTA (Coronary Computed Tomography Angiography). The purpose of this mini-review study is to understand the development of AI-assisted approaches for image processing, feature extraction, plaque recognition, and characterization in CCTA. Furthermore, the benefits, drawbacks, and potential applications of AI in diagnostic testing of atherosclerotic lesions are reviewed.

Keywords Artificial Intelligence, Atherosclerotic plaques, Coronary artery disease, Coronary Computed Tomography Angiography

INTRODUCTION

The characteristics of coronary atherosclerotic heart disease include abnormal fat metabolism, the accretion of fats in the coronary vessels, and build-up of atheromatous plaques (CAD)(Figure.2). It can cause symptoms including chest pain, tightness, or myocardial infarction, as well as luminal constriction or blockage that causes myocardial ischemia, oxygen deprivation, or necrosis.[1]. It occurs when there is a restriction in the flow of blood due to plaque formation in one of the two major arteries that supply oxygenated blood to the heart which are LCA (Left Coronary Artery) and RCA(Right Coronary Artery). The LCA branches into the Left descending artery which supplies blood to the left and front side of the heart and the circumflex artery which supplies blood to the dorsal side of the heart. The arteries that branch off from the RCA include the right descending artery and the marginal artery that supply blood to the septum of the heart[2]. Figure 1 shows the arteries present in the heart.

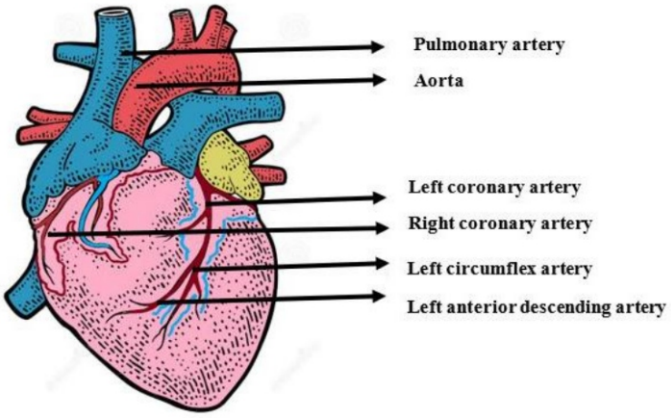
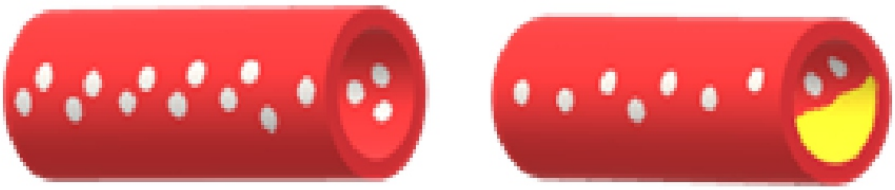


Fig 1: External view of Arteries of Heart

The most prevalent form of atherosclerosis that results in organ lesions and endangers people's lives is a heart attack. Ten million new cases of ischemic heart disease wasrecorded in 2017, and 8.9 million individuals died as a result. This illness affected 126.5 million people worldwide [1]. Key elements in the treatment of patients with hypertension include early prediction and identification of atherosclerotic plaques, categorization of their constituent parts, and risk assessment. Invasive assessments OCT(Optical Coherence Tomography) and IVUS (Intravascular Ultrasound) as well as non-invasive measurements like CT(Computed Tomography), MRI (Magnetic Resonance Imaging), and US (Ultrasonography)[3]. Due to new improvements in the sector of cardiac imaging, cardiac computed tomography angiography (CCTA) is used as the main investigation tool in patients with suspected heart stroke. CCTA provides important details on characterization of coronary artery plaque, total blood circulation, and luminal stenosis, as well as the potential to assess shape, plaque formation, and susceptibility[4], [5] . These procedures are currently conducted either manually [6] or self- operating by first using lumen segmentation and then characterizing the existence of stenosis [7].



a) Normal Artery **b) Atherosclerotic artery**

Fig2: Sectional View

Angiography is a conventional approach for diagnosing CAD that produces accurate results. This procedure is costly, invasive, and can result in consequences such arterial dissection, arrhythmia, and even death. To address these issues, the development of big data, machine learning techniques, and the availability of high computational power has resulted in various advancements in Artificial Intelligence (AI) techniques for detecting the amount of calcium present in the coronary arteries using medical image processing in recent years. For the early identification of CAD, these AI approaches are cost-effective, quick, non-invasive, and trustworthy[2]. Because it can analyse huge amounts of data in many ways, machine learning (ML), a subdivision of AI, is very helpful in CVD imaging. ML may integrate data from a multitude of sources and provide it to the practitioner in a relevant way. It can also automate a number of measures in a variety of imaging modalities. The advancement of precision medicine will be

aided by the growth of AI [8].

ARTIFICIAL INTELLIGENCE APPLICATIONS

The study of theory, techniques, systems, and applications for replicating and enhancing human brain intelligence is the focus of the field of artificial intelligence (AI) . The incorporation, retrieval, and processing of enormous datasets can benefit greatly from the use of artificial intelligence, which was extensively utilized in medical research[1,9]. Additionally, it is employed in cardiovascular medicine to identify novel disease genetic traits, enhance cost-effectiveness, and, most importantly, risk stratification[10]. The AI's therapeutic uses have actually ramped up due to the increase in the volume and accessibility of medical imaging data. Early diagnosis of the formation of coronary plaques is essential for avoiding problems, and several Computer Vision methods have been created for the automatic detection and categorization of coronary plaques. CAD technology can boost clinical workflow efficiency by boosting the precision and dependability of image interpretation [9].

Machine learning in CCTA

The three forms of machine learning are, reinforcement learning (RL), supervised learning (SL), and unsupervised learning (USL). The reinforcement learning is a cross between SL and USL where SL trains labelled samples and USL trains unlabelled samples. The model is then used to map all inputs to the right outputs, and classification is achieved by making a straightforward assessment of the outputs. It is usually important to group the data and choose features using clustering since unsupervised learning data collected is not labelled.Examples of machine learning algorithms include the Support Vector Machine (SVM), Random Forest (RF), Decision Tree (DT), Genetic Algorithm (GA), and Bayesian Network (BN) [1]. Pre-processing and segmentation, extraction of features, dimension reduction or feature grading, and classification are some of the crucial processes that these techniques are employed for. Because it increases image resolution or sharpness by using suitable filters like Gaussian and median, image pre-processing is a crucial first step. Before further categorization, the appropriate Region Of Interest (ROI) for coronary plaque identification must be extracted. The right characteristics are created utilising feature extraction strategies, processed for dimensionality reduction and then used to describe the plaques. [9].

Deep learning inn CCTA

AI algorithms have evolved efficiently in deep learning sector. Automated image identification has significantly advanced with the widespread adoption of deep learning (DL) techniques, particularly those built on a convolutional neural network (CNN) architecture [1]. DL often builds simple patterns into more complex ones. With bigger and more complex datasets, deep learning performs better than traditional machine learning frameworks. The structure of deep learning is analogous to the human neural structure. To get results from enormous data matrices that are ordered in a series of layers, data information from earlier to later levels is elaborately analysed. Other algorithms require intensive training to achieve superior outcomes. On the other hand, by boosting the training dataset or the network capacity, deep learning accuracy may be readily improved. Less domain knowledge is needed to carry out a function in DL. The famous deep learning frameworks is convolutional neural network (CNN). The initialization process involves feeding the input data into deep CNNs and propagating the data through convolution layer, pooling layer, activation unit, and dense layer. Both the feature extraction convolutional component and the classification convolutional component are fully coupled. In a fully connected network (FCNN), every unit is connected to every other unit in the level above it and the level below it. Recurrent neural networks (RNN) enrols feedback loops to evaluate a variety of inputs. CNN

algorithms may effectively streamline the image processing process, resulting in time savings and increased productivity [8].

Characterisation, Quantification and Stenosis Detection of Atherosclerotic Plaque In CCTA

In atherosclerosis (AS), the interaction of epithelial cells, lymphocytes, and smooth muscle cells is a complicated process. Intimal smooth muscle cell aggregation is a hallmark of adaptive intima thickening in atherosclerotic lesions, that can develop into pathological intima congealing, which is further identified by the proximity of capillary lipid pools. Correct plaque component identification is essential for follow-up treatment because individual aspects of atherosclerotic plaques in the coronary arteries correspond to various processes and produce various consequences. Coronary plaques can be classified as calcified, noncalcified, or mixed plaques that have both traits. [3]

Calcified plaque – It is frequently measured using specialised enhanced non-contrast, electrocardiograph triggered calcium scanning images. An advanced software is used by the specialist to identify voxels in the coronary arteries with a volume larger than 130 Hounsfield units (HU).

The calcium scoring is then measured in terms of its volume or density. Although trained doctors do not consider calcium scoring to be a difficult technique, it does require time when performed on several pictures. Therefore, to overcome this automated.ML techniques are suggested. Deep learning-based techniques have not historically been used to classify candidate lesions; instead, single voxels have [11].

Non-calcified plaque – This is frequently prone to rupture and can cause thrombosis. In CCTA, analytic techniques have been developed for non-calcified plaque localization, characterization, and identification. The finding of coronary arteries using centreline extraction is a common pre-processing step for ML-based plaque analysis. The plaque detection and identification can be improved by rebuilding the centreline CCTA images [11]

Decades of study have led to the ability to monitor atherosclerotic plaques using a range of medical imaging methods. These methods might pinpoint the morpho - physiological abnormalities brought on by atherosclerosis, thorough details on plaque formation, and perhaps even assess the likelihood of atherosclerotic plaque generation. CT and MRI are indeed the two most widely used non-invasive methods for evaluating coronary atherosclerotic plaques.

Overall component density of plaques, vasculature remodelling, and luminal stenosis can all be evaluated as well as identified and analysed using the CT scan. It hasthe ability to identify people who are asymptomatic but have high-risk plaques and classify the likelihood of cardiovascular disease as a non-invasive diagnosis. People with severe plaque are diagnosed by Major Adverse Cardiac Events (MACE) as either a standalone predictor of Acute Coronary Syndrome (ACS). The soft tissues can be well contrasted by MRI. This might also display the plaque deposition in addition to the arterial cavity and interior artery wall anatomy. The most frequent cause of ACS, the most lethal form of CAD, is susceptibility plaque rupture. Numerous inflammatory cells, a huge necrotic core, and very few smooth muscle cells are the pathogenic characteristics of the majority of vulnerable plaques. [3]

LIMITATIONS IN CAD DIAGNOSIS:

Though there are many advanced data processing and DL techniques there are also few avenues that need special and deep attention from researchers and professionals. The disadvantages in using ML techniques for CAD detection is as follows:

1. For each unique situation, a different ML approach is appropriate. While one method might work well on one dataset, it might not work well on others. As a result, picking the right algorithm for a certain dataset is crucial. Thus, selecting effective feature selection or classification is essential and posts a great and significant challenge.

2. To train ML algorithms, large datasets are typically required. These data sets must be exhaustive, balanced, and of high quality. Datasets must also be collected over time.
3. In order to provide findings with a high degree of confidence, machine learning algorithms need enough period to be programmed and analysed. These algorithms require a considerable number of materials and technology.
4. . Machine learning algorithms have difficulties with the validation problem. It's challenging to show that all of their predictions are accurate. Accurately interpreting the findings provided by machine learning techniques is still another issue we face.
5. Another downside of machine learning algorithms is their high mistake proneness. They produce imprecise outputs if they are trained with biased or wrong input. This could set off a cascade of errors, leading to treatment techniques being misled. When these problems are discovered, diagnosing the source of the faults takes time, and correcting them takes even more effort.
6. The datasets used for CAD diagnosis also has multiple issues like small sample sizes, limited features. The method of data analysis in earlier research is another issue.[2]

The mentioned shortcomings in CAD detection can be overcome by taking into consideration the following solutions
1. To find the most informative features, complex feature section approaches are used. This will result in formation of sparse model structures that are resistant to data uncertainty.
2. Model development and feature engineering computation is done using evolutionary algorithms. As a result, it boosts the accuracy of stenosis detection.
3. Algorithms for learning (ML). ML has demonstrated superhuman abilities in a variety of situations. Advances have sparked a surge in the use of deep learning to solve hard issues in a variety of industries.
4. The majority of ML-based CAD diagnosis research has focused on the development of individual models. Individually poor models can be significantly improved using ensemble-based learning (boosting and bagging) strategies [2].

CONCLUSION

The capacity of machine learning to relieve doctors of time-consuming chores and alter diagnostic methods may lead to a decrease in healthcare expenditures. In this succinct summary, atherosclerotic plaque and stenosis employing AI in cardiac CT are identified, described, and quantified. Machine learning was always at the heart of cardiac image processing, but the rise of deep learning has sped up development in the field. Artificial intelligence also has the ability to advance and enhance healthcare technologies for improved patient care by speeding up analysis times and offering professionals automated assistance on diagnosis and following treatment options. A fully convoluted network architecture algorithm for automatic identification and prevention of coronary artery plaque, as well as detection and classification of the anatomical relevance of coronary artery stenosis, will be included in a suitable workflow for the integration of machine learning and deep learning analysis of imaging modalities in clinical practise. The application of AI in cardiovascular imaging is positive due to advancements in computing, bioengineering, and medical image processing technologies, and the cooperation between researchers and doctors will be very advantageous.

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Scope & Integration of Computational Intelligence in Traditional Power Sector

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ABSTRACT

An electrical power system is an infinite vast complex network of sophisticated equipment and confederate control to ensure a sustainable energy supply. Ever-increasing power demand in the recent decade has made it difficult to maintain its viability. A rapid transformation in the internal architecture of power system infrastructure is the need of the hour to continue the fictitious lifeline. With the passage of time, electricity has become one of the most crucial elements with almost no substitute. Cutting edge energy-efficient technologies and modern generation computational tools can trigger its growth to maximize its potential, which may entirely transform the power sector scenario and make it future-ready. It is predicted that the adoption of artificial intelligence mutually with data science must have a remarkable outcome to incorporate and develop automation and move towards a smart grid by slashing energy consumption, lowering prices, enhance transparency, gear up efficiency and boost clean green renewable sources globally. AI can further improve the planning, operation, and intelligent control of power systems. Data-intensive technologies can be introduced in diverse dimensions of the electricity value chain following an authentic road map which may considerably reduce the conventional challenges and create significant value. In this work, the authors have attempted to study, investigate, and explore the Power System's present outline in context to India and summarize future possibilities, difficulties, and specific outcome in a systematic, logical manner. This novel work shall benefit distinct researchers and dynamic academicians to get a fundamental idea and strengthen their existing knowledge over the subject.

Keywords : AI, automation, cloud computing, data science, Energy, management, power system.

INTRODUCTION

Artificial intelligence (AI) can play an essential role in changing economies and industries, such as the electricity market worldwide. It is still early days in the implementation of AI in the energy and infrastructure sectors, but several possible uses are emerging. It is believed that artificial intelligence (AI) would revolutionize every industry on the planet, including the power market. The whole power market is going through a revolution owing to digitization. The energy market does not seem to be as it was in the '20s. Utilities focus on employing Artificial Intelligence (AI) principles around Big Data, predictive analytics, and machine learning (ML). As of now, it is only in the early stages of general implementation; there are already various ways in which AI has been applied in the electricity and services sectors. Cognitive processing has anticipated to become the nervous centre of the potential smart grid. A centralized national sensor network system hub can constantly accumulate and evaluate vast volumes of data from millions of sensors to identify the health of power infrastructure periodically. Additionally, 'deep learning algorithms can boost both the supply and demand aspects of the energy market. As a consequence, microgrids would overtake regional systems that meet broader electricity requirements. Customers can also benefit from smart meters and transmission sensors which allow for constant demand and supply monitoring. Additionally, 'synchronogists'

briefcase-sized instruments are built to monitor flow speeds to eliminate interruptions in the system. This sensor would operate with the grid to modulate the power supply to lower the utility bills' stress for customers. With the growing usage of artificial intelligence, the industry will move to an energy portfolio of sustainable energies, variable supply, and limited intermittency disturbance. Climate change and its subsequent ever-growing need for green power would cause a severe energy industry crisis as its integration in the existing power ecosystem to have several quality and stability issues. AI, robust data science algorithm and analytics prove beneficial by dynamically control the energy produced from numerous power generation resources to meet shifting temporal, geographical, and social needs in real-time.

LITERATURE SURVEY

Renewable energy sources are very significant and beneficial to meet ever-increasing energy requirements sustainably. Though traditional sources might last a little longer, it is not just the availability but also the affordability. Quiet often third world countries with fragile economies suffer from an energy crisis. It is a well-recognized and acknowledged reality that green renewable resources are emerging; more efficient energy sources are bound to be significantly more acceptable in the potential due to their low prices and environmental friendliness. India has tremendous potential to harness diverse non-conventional green energies and other sustainable energy forms, with ample solar resources. The supply of electricity was indeed a crucial factor in national prosperity. The success story of modern India since Independence is remarkable. The power sector also has been similarly hit by the global financial crisis. Over the period from 1947 until now, the per capita intake has risen 12-fold from 16 kWh to 1,181 kWh. The overall amount of infrastructure that caters to this demand falls under the word "Power Scenario." In this area, future electricity generating capacities and distribution channels need to be thoroughlyexamined. The necessity of the hour is to consider and address the potential issues that arise in this field first, which may prevent its growth and accessibility. Innovative computational tools may act as a game-changer to revolutionize and transform the rudimentary power sector concept and accountability by a systematic, sustainable outcome-based approach. In 2018 L. Wencui et al. has investigated a detailed case study on the Information Security Prevention System of electric grid based on AI tools [1]. S. Kokin et al. has presented a fantastic Optimisation strategy of electrical power system modes by implementing artificial intelligence, which was a remarkable research outcome in 2020 [2]. A. Jalilvand et al., in the year 2010, has studied and explored the design of an energy-efficient PID power system stabiliser in a multi-machine power system using computational intelligence methods [3]. H. Yu and G. Shao [4] in 2019 examined and reviewed the Reactive Power of Electric Drive System of Remote Pump Station utilising Artificial Intelligence Control strategy. In 2019 C. Darab et al. has analysed and reconsidered Fault Location and Detection in Distributed Generation Power Systems using the Machine learning & Data Science approach [5].

In his previous work, the authors have studied, investigated, explored, & examined various physical parameter/triggering conditions that affect power system operation, remote health-monitoring, innovative troubleshooting techniques author after exhaustive literature review, has observed much less progress has been reported in the domain of intelligent power system and application of computational tools in solving real-time problems in the recent time. However, numerous scientific research activities are needed to be nurtured and carried out to promote the New Generation power network concept. The author of this work has tried to present an overview of recent research findings and development, possible challenges, and scope for further improvement.

SMART GRID MARKET DYNAMICS

By 2025, the global smart grid market is estimated to be worth USD 94.7 billion. Energy initiatives and activities such as green electricity infrastructure, intelligent metres, energy-efficient resources, and smart appliances are also part of smart grid technologies. Furthermore, the smart grid employs hardware technologies such as security cameras, sensors, and others to detect electricity demand and control the systems. Smart grids may use devices to switch on and off power when the networks are not in use, resulting in lower energy usage. The smart grid offers technologies that increase fault identification and enable the network to self-heal during power outages. Smart Grid enables real-time control and management of the power sector while also assisting in the reduction of AT&C losses. Smart Grid is intended to act as a backbone network to implement emerging market models such as hybrid cars, smart towns and societies. The worldwide market for smart grids is segmented by component, solutions, application, end-user, and geographic region. The industry is split into two components: solutions and facilities. It is categorised into four groups based on application: generation, transmission, distribution, and consumption/end-use. The sector is divided into advanced metering technology (AMI), substation automation, smart grid security, connectivity, network management and other based solutions.

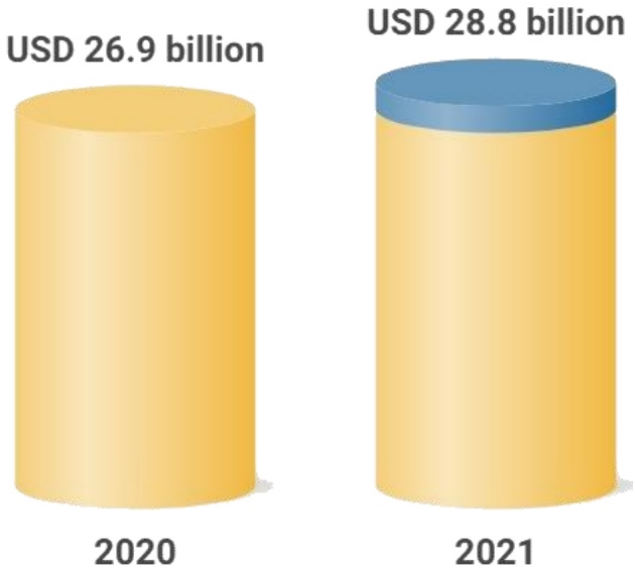

Fig.1: Asia Pacific smart grid market 2020-21 [2]

The existing and prospective potential of smart grid industry dynamics is driving the market's overall attractiveness. During the forecast era, the top influencing factors illustrate the smart grid business opportunities. The increasing concern regarding environmental protection is a primary factor influencing the demand growth for intelligent grid systems. Furthermore, rising favourable government legislation and intelligent metre deployment policies are the main drivers driving demand for innovative grid technologies and services. However, safety and protection issues aroundsmart grid systems are a significant impediment to the smart grid industry's development. Increased smart city projects and government programmes are projected to create substantial growth prospects for the sector in the coming years. Below two charts has been shown with the Asia-pacific smart grid market with an expected steady growth rate of 7.1%, i.e., Fig. 1 and on the other hand, Fig.2 shows existing and future projection of Smart grid infrastructure market of key notable countries in terms of USD.

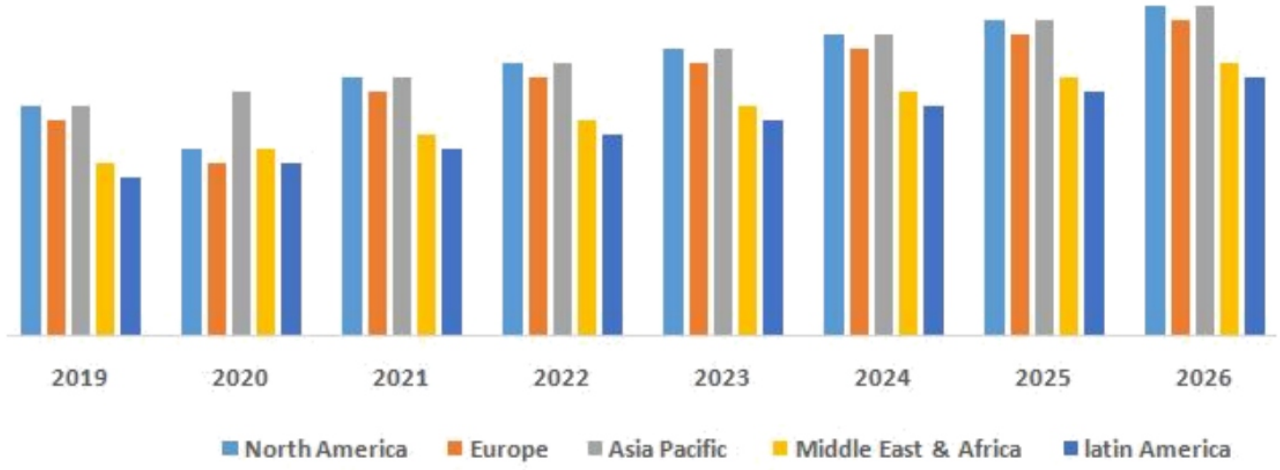

Fig. 2: Smart Grid Energy Market worldwide for 2019 to 2027 [3]

NECESSITY OF AI & DS IN POWER SECTOR

The sophistication of the power system networks has risen significantly as the energy structure has expanded. As a result of this power system research using traditional methods, drawing assumptions from the collected data, the details, remote device control, and utility management processes have become more complex and time-consuming. AI is built with the assistance of advanced programming software and implemented to solve all of the above problems for massive power structures, as the requirement is the mother of innovation. The need for Power Systems architecture with Artificial Intelligence is primarily because of the complexity, flexibility, and extensive knowledge used in the measurement, diagnosis, and learning. Moreover, using traditional techniques becomes more stressful due to the massive device data processing, the computing period, and precision have increased. Understanding the pivotal role data plays in AI's vast complexity helps examine the technology's varied encapsulating and overlapping approaches (Fig. 3). artificial intelligence encapsulates several concepts, including 'natural language processing' (NLP), 'deep learning' (DL), and 'neural networks' (NN).

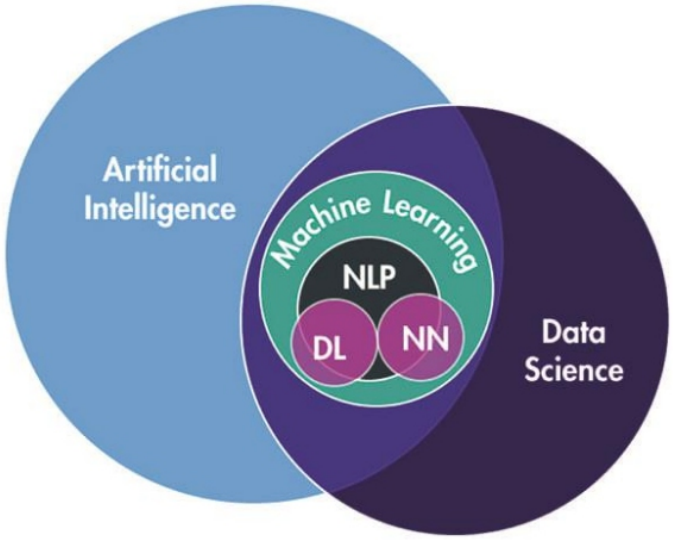

Fig.3: Different sectors of Computational Intelligence

RECOMMENDED AI TECHNIQUES

From the early to mid-1980s, finding solutions to complex issues in numerous power system innovation fields was difficult and time-consuming. Many restrictions can now be efficiently handled using Artificial Intelligence (AI), such as economic load dispatch, load forecasting, generation, and scheduling optimization, transmission ability and optimum power flow, actual and reactive power limits of generators, bus voltages and transformer taps, load demand in interconnected extensive power systems and their protections, and so on. AI methods have successfully eliminated the majority of the efforts of power system research. Modern power infrastructure includes essential families of AI techniques, i.e., Fuzzy Logic systems (FLS); Genetic algorithm (GA); Artificial Neural Networks (ANNs); Expert System Techniques (XPS), and so on.

AAN: Artificial Neural Networks

ANN are biologically motivated structures. Each neuron generates one output as a function of inputs in ANN mathematical models, which simulate the human biological neural network for information processing. After being learned, each form of the neural network is capable of completing a feature based on insights encountered in real life, such as function approximation, recognition, data processing. Its main advantages are the ability to learn algorithms, online dynamic machine adaptation, fast parallel computation, and intelligent data interpolation. Their architecture, number of layers, topology, communication pattern, feedforward, backpropagation, and radial base function or recurrent, among other factors, are used to classify them. ANNs are dissolute and efficient, and they do not need any previous knowledge of the device model. They can tolerate missing or corrupt data and details because they are fault-tolerant. They have understanding and data adaptation potential. ANNs, on the other side, can only execute the purpose for which they were programmed. They must be retrained for some other mission. ANNs often produce a verdict, even though the input data is illogical. ANNs are particularly useful for problems requiring quick performance, such as those in real-time operations. Power device security may benefit from ANN techniques.

Real-world challenges in power production, storage, and delivery may be fed into ANNs for a solution.

FLS: Fuzzy Logic systems

Fuzzy structures were invented in 1965 and quickly gained popularity in scientific problem-solving. Instead of an exact mathematical interpretation, they are regarded as mathematical means of explaining complexity in linguistic words. Since it works and can make decisions like a human brain, approximate logic can be standardized and systematized. As a result, it provides precise solutions with limited or even approximate knowledge and details. As a result, this technology is used in computers to mimic human performance. Fuzzification allows for oversimplification, superior expressive capacity, and a better opportunity to model a complicated problem at a low expense. It requires a certain degree of ambiguity in analysis, and as a result of the permitted uncertainty, it reduces problem complexity and defines facts. Fuzzy logic can be used in power system applications such as reactive power & voltage management, system stability analysis and control, fault analysis, security evaluation, load forecasting, power system safety, and so on. It may be used to improve performance as well as to build physical components of power systems ranging from small circuits to massive mainframes. Since most of the utmost power system research is done with approximation or assumption-based results, fuzzy logic can help obtain a consistent and exact output free of uncertainty.

XPS: Expert System Techniques

Expert technologies were built in the 1960s and 1970s and commercialized in the 1980s. It is often

referred to as a knowledge-based method or a rule-based system. Computer software uses information derived from experts on a particular topic to provide users with problem analysis. This information is usually saved in one of many formats, such as rules, decision trees, templates, and frames. It implements this knowledge and interface mechanism to solve problems that are either hard or challenging to solve using human ability and intelligence. A computer program providing rules for interpretation and advice for users is the most famous example of an expert framework. Since expert systems are essentially computer programs, they are built on the method of writing codes, which is more accessible than simply measuring and estimating parameter values. As a result, specific changes can be made quickly, often after the concept has been completed. These programs are incapable of accepting non-programmed issues or conditions. Expert networks are beneficial where a vast volume of data and knowledge must be handled in a limited period. Many power systems applications relating to power system architecture and study are compatible with expert systems' capabilities.

GA: Genetic algorithm

The Genetic algorithm has a global strategy focused on biological metaphors. It is an optimization method focused on the study of "Natural Selection and Natural Genetics." Several approaches for improving performance and power system analysis to improve power production may be suggested, but Genetic Algorithms outperform all chosen constraints. It is the most effective approach for dealing with dynamic and nonlinear problems. It is used for power supply, storage, and delivery preparation. It modifies the excitation parameters to address the voltage regulation and reactive power compensation problems.

KEY CHALLENGES NEED TO BE ADDRESSED

Advanced technology is permeating every sector of the global economy, including the electricity sector. Computational intelligence has the ability to overhaul this industry around the world entirely. AI is supposed to progress from a valuable technology to the most effective decision-maker the electricity market has ever seen. It is expected to minimise manual labour, reduce costs, and enhance data and asset protection. However, before the promising future can arrive and AI can revolutionise the energy market, several obstacles must be needed to overcome, below few are addressed for better understading.

Inadequate theoretical framework

One explanation for the sluggish implementation of AI in the energy sector is a lack of decision-makers awareness of AI technologies. Many businesses actually lack the technological knowledge required to realise how AI will support their operations. Conservative stakeholders would rather stay with tried-and-true approaches and tools than take a chance with the fresh. If more markets, such as schooling, banking, healthcare, and transportation, recognise AI's potential, decision-makers in the energy sector shall follow it.

Incompetent pragmatic knowledge

AI is still a newer concept, and experts who have mastered it are few. There are numerous experts with comprehensive theoretical knowledge of the topic. However, it is exceedingly difficult to find experts capable of developing robust AI-powered applications of real-world utility. Furthermore, the oil market is notoriously traditional. Even though energy firms gather and maintain info, digitising it using cutting-edge technology is problematic. Data loss, bad customisation, server malfunction, and unauthorised access are both threats. Since the risk of error is considerable in the energy sector, many businesses are afraid to pursue innovative methods for which they are inexperienced.

Antiquated Infrastructure

The most crucial impediment to energy sector transformation is the ageing infrastructure. Currently, energy providers are trapped under a mountain of data that they have collected and have little idea how to do with it. While the business has more data than anyone, that data is often dispersed, disorganised, dispersed through several platforms, and often processed locally. Although the industry makes a lot of money, it still loses much money because of old structures' flaws.

Financial stress

Implementing advanced smart technologies in the energy sector might be the safest alternative, but it is far from the cheapest. It requires a lot of time and money to locate an experienced software services supplier, build and configure software, modify, maintain, and track it. Until companies in the energy industry enjoy the advantages by integrating AI, artificial learning, and deep learning into their plans, they must be prepared to devote a sizable budget and recognise the uncertainties involved with updating obsolete technologies.

EXPOSURE OF AI & DATA SCIENCE IN POWER SYSTEM

A reliable and adequate electricity supply has been a necessity of the planet to prevent environmental effects. This is accomplished by careful control of power system facilities and consumption. It necessitates AI-based strategies that are highly secure, precise, and automatic systems such as EMS, Intelligent sub-stations adorned with high-speed security, tracking, and communication systems. Savings in the fields of remote control of facilities, operation, repair, and manufacturing may be realized by promoting these advances with AI techniques. Much research has been done, and a lot more research is needed to reap the maximum benefits of AI technology for cost reduction by enhancing the performance of the power grid, distributed control and monitoring system, renewable energy resources system, and electricity market and investment system.

Several challenges with power networks cannot be addressed using traditional approaches. As a consequence, AI strategies in power device implementations are attracting much interest. Outage detection and prediction begin with the selection of the appropriate metrics and their threshold values. Any outage case should be thoroughly investigated to determine the root cause. Only then can statistical algorithms be used to forecast the probability of an outage in the future. The usage of intelligent electricity failure ecosystems facilitates reliable real-time outage statuses to enhance overall consumer service and retention. Some of the areas of the power scheme applications are highlighted here.

Economic load dispatch, generation, organizational preparation dependent on load forecasts, hydrothermal generation scheduling optimization, power transmission capability, optimum power transfer, generator actual reactive control restrictions, and device efficiency

Dynamic energy management, real-time customer billing, improving operational efficiency, optimizing asset performance, analysis of energy prices and auction tactics, enhancing customer experience, Smart Grid security and theft detection, preventive equipment maintenance, demand response management

Distribution planning and service, network reconfiguration, demand-side reaction and management, innovative grid operation and control, power restoration, fault detection, and protection margins may all be automated

Voltage and frequency management for machine reliability, sizing, and control of FACTS systems

SPECIFIC OUTCOME & DISCUSSION

This paper reviews the latest artificial intelligence applications in power systems, such as artificial neural networks, expert systems, and fuzzy theory. These applications have the enormous potential to vastly improve power system performance, minimize human and material resource input, and play a critical role in power system defense. It is projected that the power system's scale will continue to increase in the coming years, as will its complexity, which will bring some more difficult factors to deal with. Some artificial intelligence already has its range of remarkable opportunities, restraints, limitations, and a lack of a sustainable roadmap, applied to the compelling hybrid intelligent. It is believed that in the future, as research advances, computational intelligence may become more advanced and simpler to use, allowing it to help solve real-time difficulties in power systems. Integrating a range of innovations with computational intelligence would be a big trend in growth prospects in a nutshell. Injection of more eco-friendly EVs near future market needs next-generation charging infrastructure with 24x7 power availability which is needed to be ensured by the application of computational intelligence and sophisticated, cutting-edge technologies which have a unique role in transforming centralized power system into numerous smart microgrid, in turn promotes the adoption of more renewable captive energy power sources and thus moves towards a greener, sustainable future.

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