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Empirical Study of Artificial Neural Networks in Face-Recognition

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Abstract: Artificial Neural Network is an Information Processing Paradigm which is inspired by the way Biological Nervous Systems from the brain, process information. The key element of this paradigm is the structure of the information processing system, which is same as the neurons pass the information between neurons within the brain. It is composed of many numbers of highly interconnected processing elements (neurons) to solve specific problems. Artificial Neural Networks are essentially artificial neurons configured to carry out a specific task, like people, learn by examples. An Artificial Neural Network is configured for specific applications, such as pattern recognition, data classification, clustering, prediction, determining outliers through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons to form a network of Neurons or nodes. Face recognition is discussing about the how the face can be recognized by using some algorithms. This is fact of ANNs as well and operates the massive computational elements in parallel to achieve high performance speed. This paper discusses about the Pros and Cons of Face Recognition in Artificial Neural Networks, Comparisons for Machine Learning and Artificial Neural Networks and Various Organizations are Using Face Recognition.

Keywords - Artificial Neural Networks, Prediction, Clustering, Machine Learning, Face Recognition.

1. Introduction

Artificial Neural Network (ANN) is the study of the Human Brain is thousands of years old. With the advent of modern electronics and computerized world, it was only natural way to try to harness this thinking process. The first step toward artificial neural networks came in 1943 when Warren McColloch neurophysiologist, and a young mathematician, Walter Pitts, wrote a paper on how neurons might work. They modeled a simple neural network with electrical circuits. Neural networks use the processing of the brain as a basis to develop algorithms that can be used to model patterns and prediction problems. In our brain, there are billions of nerves or cells called neurons, which processes information in the form of electric signals. External information is received by the dendrites of the neuron, processed in the neuron cell body, converted to an output and passed through the Axon to the next neuron. The next neuron can choose to either accept it or reject it depending on the strength of the electric signal [1]

1.1. Artificial Neural Networks (ANNs):

Artificial Neural Networks (ANN) is inspired by the human brain and can be used for machine learning and artificial intelligence. With these networks, various problems can be solved computer-based. [2]

Steps involved in Neural Network of Human body are:

Step-1: External signal is received by dendrites.

Step-2: External Signal processed in the neuron cell body

Step-3: processed signal and transmitted through the Axon

Step-4: Output signal received by the dendrites of the next neuron through the synapse.

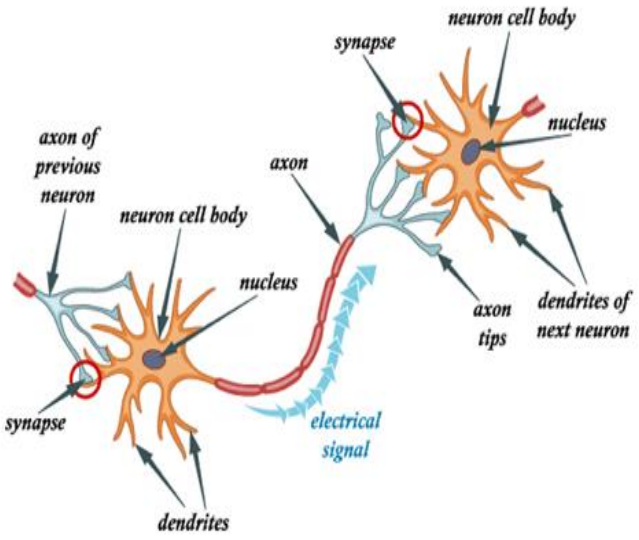


Fig 1. (Neuron in Human Body)

Now, let's try how an artificial neural network works as follows:
Step-1: Inputs are sent through input layers.
Step-2: Input processing is done within the Hidden Layer-1
Step-3: Output processing and transmission is done with in the Hidden Layer-2
Step-4: Output received to output layer.

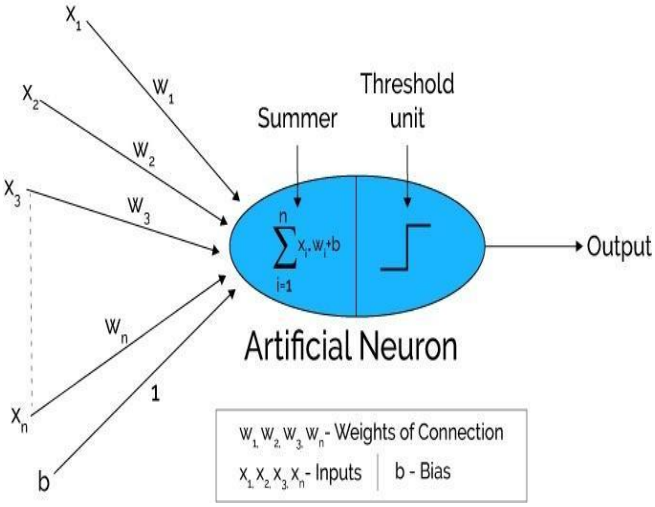


Fig 2: Artificial Neuron

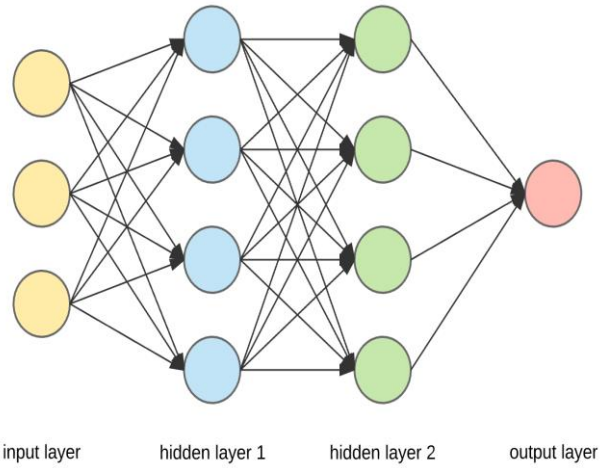


Fig 3: Artificial Neural Networks

1.2. Difference Between the Biological Neural Networks and Artificial Neural Networks:

Table 1 : Differences between ANN and BNN

Biological Neural Networks (BNN)	Artificial Neural Networks (ANN)
Biological neuron or Nerve cells	Silicon transistors
200 billion neurons,32 trillion interconnections.	1 billion bytes RAM, trillion of bytes on disk
Neuron size:10-6 m.	Single transistor size: 10-9 m.
Energy consumption:6-10 joules per operation per second.	Energy consumption: 10-16 joules per operation per second.
Learning capability	Programming capability

1.3. Machine Learning in ANN:

ANNs are capable of learning and they need to train. There are many learning Strategies: -

1. **Supervised Learning:** It required a teacher that is scholar than the ANN itself.

Ex: The Teacher teaches some data about which the teacher already knows the answers.

2. **Unsupervised Learning:** It is required when there is no example data set with known answers.

Ex: searching for a hidden pattern. In this case, clustering i.e. dividing a set of elements into groups according to some unknown pattern is carried out based on the existing data sets present

3. **Reinforcement Learning** − this strategy built on observing. The ANN makes a decision by observing its environment. If the observation is

negative, the network adjusts its weights to be able to make a different required decision by the next time [3].

1.4. Artificial Neural Networks Currently Trends in Machine Learning:

Today, we are living in the exciting time where technology is expanding at a cracking place. Of late, we have seen major innovation happen, right from Chabot's to self-driving cars, to sales force automation & machine automation; all clearly depicting that AI and its advancements are going to transform the world by taking a leap in every industry segment [6].

There are several types of Artificial Neural Networks currently in trending are: Feedback Neural Network – Artificial Neuron

1. Radio basis function Neural Network
2. Korhonen self-organizing Neural Network
3. Recurrent Neural Network – Long Short-term memory
4. Convolution Neural Network
5. Modular Neural Network
6. Deep Learning
7. Hybrid Systems
8. Neuro-Genetic
9. Neuro-Fuzzy
10. Implementation of a Hybrid Neural Network

In the future, AI will lay the foundation for a new era in computing with these breakthroughs.

1.5 Applications of Neural Networks are:

They can perform tasks that are easy for a human but difficult for a machine – [4]

- **Aerospace** −Autopilot aircrafts, aircraft fault detection.
- **Automotive** −Automobile-guidance systems.
- **Military** − Weapon orientation and steering, target tracking, object discrimination, facial recognition, signal/image identification.
- **Electronics** −Code sequence prediction, IC chip layout, chip failure analysis, machine vision, voice synthesis.
- **Financial** −Real estate appraisal, loan advisor, mortgage screening, corporate bond rating, portfolio trading program, corporate financial analysis, currency value prediction, document readers, credit application evaluators.
- **Industrial** −Manufacturing process control, product design and analysis, quality inspection systems, welding quality analysis, paper quality prediction, chemical product design analysis, dynamic modeling of chemical process systems, machine maintenance analysis, project bidding, planning, and management.
- **Medical** −Cancer cell analysis, prosthetic design, transplant time optimizer. EEG and ECG analysis,
- **Speech** −Speech-recognition, speech classification, text to speech conversion.
- **Telecommunications** −Image and data compression, automated information services, real-time spoken language translation.
- **Transportation** −Truck Brake system diagnosis, vehicle scheduling, routing systems.
- **Software** −Pattern Recognition in facial recognition, optical character recognition, etc.
- **Time Series Prediction** − ANNs are used to make predictions on stocks and natural calamities.
- **Signal Processing** − Neural networks can be trained to process an audio signal and filter it appropriately in the hearing aids.
- **Control** − ANNs are often used to make steering decisions of physical vehicles.
- **Anomaly Detection** − ANNs are expert at recognizing patterns, they can also be trained to generate an output when something unusual occurs that misfits the pattern.
- **Classification-** Classification, the aim is to predict the class of an input vector
- **Pattern matching-** Pattern matching, the aim is to produce a pattern best associated with a given input vector
- **Pattern completion-** Pattern completion, the aim is to complete the missing parts of a given input vector
- **Optimization**- Optimization, the aim is to find the optimal values of parameters in an optimization problem
- **Control**- an appropriate action is suggested based on given an input vector
- **Function approximation/times series modeling**- Function approximation/times series modeling, the aim is to learn the functional relationships between input and desired output vectors
- **Data mining** -Data mining, with the aim of discovering hidden patterns from data (knowledge discovery)
- Human Face Recognition
- Signature Verification Application
- Chatbot's
- Stock Market Prediction

1.6. Different Techniques of Neural Networks:

1. Classification Neural Network
2. Prediction Neural Network
3. Clustering Neural Network
4. Association Neural Network

The Above Techniques of neural networks are discussed below: [5]

1. Classification Neural Network:

A Neural Network where we can classify given pattern or dataset into predefined classes. It uses Feedforward Networks.

2. Prediction Neural Network:

A Neural Network where we can produce outputs that are expected from given input.

Ex: – Stock market prediction and Heart attack prediction

3. Clustering Neural Network:

The Neural network can be used to identify a unique feature of the data and classify them into different categories without any prior knowledge of the data.

4. Association Neural Network:

A Neural Network can be trained to remember the pattern so that when the noise pattern is presented to the network, the network associates it with the closest one in the memory or discard it.

Ex: Hopfield Networks which performs recognition, classification, and clustering, etc.

2. Neural Networks for Pattern Recognition:

Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of interest from their background, make sound and reasonable decisions about the categories of the patterns.

Some examples of the patterns are: Fingerprints image, a handwritten word, human Face and speech signal. [7]

This given input pattern, its recognition involves the following tasks –

1. **Supervised Classification:** Given input pattern is identified as the member of the pre-defined class.
2. **Unsupervised Classification:** Pattern is assigned to a hitherto unknown class.

So, The Pattern recognition problem here is essentially classification task.

The design of the pattern recognition system usually involves the following three aspects-

- Data acquisition and pre-processing
- Data representation
- Decision making

2.1 Approaches for pattern Recognition:

- Template matching
- Statistical
- Syntactic Matching
- Artificial Neural Networks

Following are the neural network architectures used for pattern recognition-

- Multilayer Perceptron
- Kohonen SOM (Self Organized Maps)
- Radial Basis Function Network (RBF)

2.2 Advantages of Artificial Neural Networks (ANN):

- Alters to Unknown conditions
- Powerful
- It can model difficult functions
- Ease of use
- Can be imposed in any application
- **Storing information on the entire network**: Information such as in **traditional programming** is stored on the entire network, not on a database. The disappearance of a few pieces of information in one place does not prevent the network from functioning.[8]
- **Ability to work with incomplete knowledge**: After ANN training, the data may produce output even with incomplete information. The loss of performance here depends on the importance of the missing information.
- **Having fault tolerance:** Corruption of one or more cells of ANN does not prevent it from generating output. This feature makes the networks fault tolerant.
- **Having a distributed memory:** For ANN to be able to learn, it is necessary to determine the examples and to teach the network according to the desired output by showing these examples to the network. The network's success is directly proportional to the selected instances, and if the event cannot be shown to the network in all its aspects, the network can produce false output
- **Gradual corruption:** A network slows over time and undergoes relative degradation. The network problem does not immediately corrode immediately.
- **Ability to make machine learning:** Artificial neural networks learn events and make decisions by commenting on similar events.
- **Parallel processing capability:** Artificial neural networks have numerical strength that can perform more than one job at the same time.

2.3 Disadvantages of Artificial Neural Networks (ANN):

- Forget
- Not exact
- Large complexity of network structure
- The neural network needs the training to operate
- Requires huge processing time for large neural networks
- **Hardware dependence:** Artificial neural networks require processors with parallel processing power, in accordance with their structure. For this reason, the realization of the equipment is dependent. [8]
- **Unexplained behaviour of the network:** This is the most important problem of ANN. When ANN produces a probing solution, it does not give a clue as to why and how. This reduces trust in the network.
- **Determination of proper network structure:** There is no specific rule for determining the structure of artificial neural networks. Appropriate network structure is achieved through experience and trial and error.
- **Difficulty of showing the problem to the network:** ANNs can work with numerical information. Problems must be translated into numerical values before being introduced to ANN. The display mechanism to be determined here will directly influence the **performance of the** network . This depends on the user's ability.
- **The duration of the network is unknown:** The network is reduced to a certain value of the error on the sample means that the training has been completed. This value does not give us optimum results.

3. Face Recognition

Face recognition is nothing new but the advanced technology due to artificial intelligence created a revolutionized facial recognition system. When AI was embedded into facial recognition tools, a smart engine was created which shows us the importance of visual content and the rise of visual data software. That is what old face recognition systems were lacking. Therefore, there were no "**smart surveillance cameras**" before AI. Now a days, Facial recognition has become faster and more accurate under all conditions, from different angles. [10]

Facial recognition is a category of biometric software that maps an individual's facial features mathematically and stores the data as a face print. The software uses deep learning algorithms to compare a live capture or digital image to the stored face print in order to verify an individual's identity.

Face recognition has become more significant and relevant in recent years owing to its potential applications. Since the faces are highly dynamic, here more issues and challenges to solve, researchers in the domain of pattern recognition, computer vision and artificial intelligence have proposed many solutions to reduce such difficulties so as to improve the robustness and recognition accuracy. As many approaches have been proposed, efforts are also put in to provide an extensive survey of the methods developed over the years. The main objective of this paper is to provide a survey of face recognition that appeared in many researches over the past decade under all severe conditions that were not discussed in the previous survey and to categorize them into meaningful approaches, appearance based, feature based, and soft computing based. A comparative study of pros and cons of these approaches have been presented.

3.1 History of facial recognition technology

During 1964 and 1965, Bledsoe, along with Helen Chan and Charles Bisson, worked on using the computer to recognize human faces (Bledsoe 1966; Bledsoe and Chan 1965). He was proud of this work, but because the funding was provided by an unnamed intelligence agency that didn't allow much publicity, little of the work was published.[10] Based on the available references, it was revealed that the Bledsoe's initial approach involved the manual marketing of various landmarks on the face such as the eye centers, mouth, etc., and these were mathematically rotated by computer to compensate for variation. The distances between landmarks were also automatically computed and compared between images to determine identity. [10]

Given a large database of images and a photograph, the problem was to select from the database a small set of records such that one of the image records matched the photograph. The success of the method could be measured in terms of the ratio of the answers list to the number of records in the database. Bledsoe described the following difficulties:

"This recognition problem is made difficult by the great variability in head rotation and tilt, lighting intensity and angle, facial expression, aging, etc. Some other attempts at face recognition by machine have allowed for little or no variability in these quantities. Yet the method of correlation (or pattern matching) of unprocessed optical data, which is often used by some researchers, is certain to fail in cases where the variability is great. In particular, the correlation is very low between two pictures of the same person with two different head rotations [10]."
--- Woody Bledsoe, 1966

This project was labeled **man-machine** because the **human extracted the coordinates** of a set of features from the photographs, which were then used by the computer for recognition. Using a **graphics Tablet** (GRAFACON or RAND TABLET), the operator would extract the coordinates of features such as the **center of pupils**, the **inside** corner of **eyes,** the **outside** corner of **eyes,** point of widows peak, and so on. From these coordinates, a list of 15-20 distances, such as width of **mouth** and width of **eyes**, **pupil** to **pupil**, were computed. These operators could process about 40-45 pictures an hour.

To accomplish this normalization, the program first tries to determine the tilt, the lean, and the rotation. Then, using these angles, the computer undoes the effect of these transformations on the computed distances. To compute these angles, the computer must know the three-dimensional geometry of the head. Because the actual heads were unavailable later on by In 2006, the performance of the latest face recognition algorithms were evaluated in the Face Recognition Grand Challenge (FRGC). High-resolution face images, 3-D face scans, and iris images were used in the tests. The results indicated that the new algorithms

There are different types of face recognition algorithms, for example:

- Eigenfaces (1991)
- Local Binary Patterns Histograms (LBPH) (1996)
- Fisher faces (1997)
- Scale Invariant Feature Transform (SIFT) (1999)
- Speed Up Robust Features (SURF) (2006)

Each method has a different approach to extract the image information and perform the matching with the input image. However, the methods Eigen faces, and Fisher faces have a similar approach as well as the SIFT and SURF methods [10].

3.2 LBP Algorithm:

Local Binary Pattern (LBP) is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. [12]

Using the LBP combined with histograms we can represent the face images with a simple data vector.

As LBP is a visual descriptor it can also be used for face recognition tasks, as can be seen in the following step-by-step explanation. It contains the following steps.

- **Parameters:** the LBPH uses 4 parameters:
- **Radius**: the radius is used to build the circular local binary pattern and represents the radius around the central pixel. It is usually set to 1.

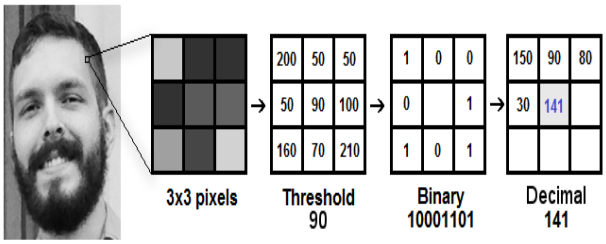
1. Neighbors: The number of sample points to build the circular local binary pattern. Keep in mind: the more sample points you include, the higher the computational cost. It is usually set to 8.

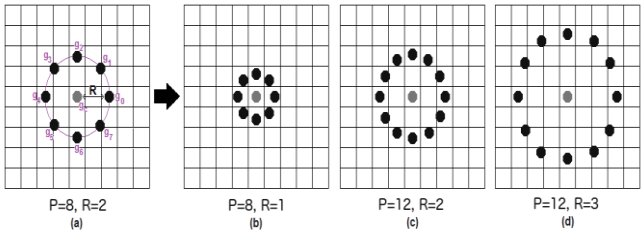
- **Grid X**: the number of cells in the horizontal direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is usually set to 8.
- **Grid Y**: the number of cells in the vertical direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is usually set to 8.

2.Training the Algorithm: First, we need to train the algorithm. To do so, we need to use a dataset with the facial images of the people we want to recognize. We need to also set an ID (it may be a number or the name of the person) for each image, so the algorithm will use this information to recognize an input image and give you an output. Images of the same person must have the same ID. [12]

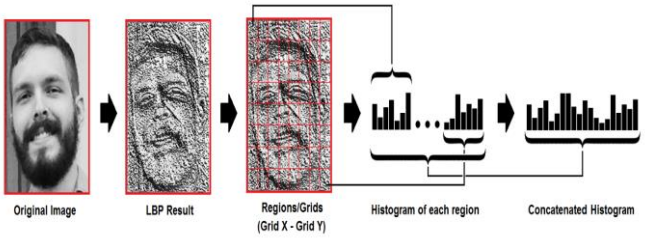
3.Applying the LBP operation: The first computational step of the LBPH is to create an intermediate image that describes the original image in a better way, by highlighting the facial characteristics. To do so, the algorithm uses a concept of a sliding window, based on the parameter's radius and neighbors.

The image below shows this procedure:





4. Extracting the Histograms: Now, using the image generated in the last step, we can use the Grid X and Grid Y parameters to divide the image into multiple grids, as can be seen in the following image:



5. Performing the Face Recognition

In this step, the algorithm is already trained. Each histogram created is used to represent each image from the training dataset. So, given an input image, we perform the steps again for this new image and create a histogram which represents the image.

3.3 Face recognition Pros:

- Increased Security
- Easy Integration Process
- High Accuracy Rates
- Fast and Accurate
- Full Automation
- Forget the Time Fraud
- No Contact

3.4 Face recognition cons:

- Processing & Storing
- High Implementation Costs
- Image Size & Quality
- Surveillance Angle Changes in Appearance and Camera Angle.

3.5 Face Recognition Software Features are:

Below Features shows how Face Recognition software is useful as follows:

- Emotion Detection
- Age Detection
- Gender Detection
- Attention Measurement
- Sentiment Detection
- Ethnicity Detection

3.6 Applications of Face Recognition:

Below are some of the applications of Face Recognition they are: [11]

- Unlocking Phones
- Finding missing person
- Smarter advertising
- Prevent Retail crime
- Protect law enforcement
- Aid Forensic investigations
- Identifying people on social media platforms
- Diagnose diseases
- Recognize VIPs at sporting Events
- Protect schools from threats
- Track school attendance
- Casinos
- Facilitate Secure Transactions
- Validate Identity at ATMs
- Make Air Travel more convenient
- Find Lost Pets
- Recognize Drivers
- Control Access to Sensitive Areas

3.7 Different Organizations are using Face Recognition:

Table-2: Difference *Organizations are using Face Recognition*

	Kairos	Amazon	Google	Microsoft	IBM	Affective	OpenCV
Face Detection	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Face Recognition (Image)	**Yes**	**Yes**	**No**	**Yes**	**No**	**No**	**No**
Face recognition (Video)	**Yes**	**No**	**No**	**No**	**No**	**No**	**Yes**
Emotional depth (%)	**Yes**	**No**	**No**	**Yes**	**No**	**Yes**	**No**
Emotions Present (Y/N)	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**
Age & Gender	**Yes**	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**No**
Multi-Face Tracking	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
SDK	**Yes**	**No**	**No**	**No**	**No**	**Yes**	**Yes**

API	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	
Ethnicity	**Yes**	**No**	**No**	**No**	**No**	**No**	**No**

Above table, shows that different organizations using Face-recognition

3.8 Machine Learning vs. Neural Network:

Table-3: Difference between machine learning and Artificial neural networks

	Machine Learning	**Artificial Neural Networks**
Definition	Machine Learning is set of algorithms that parse data and learns from the parsed data and use those learning's to discover patterns of interest.	Neural Network or Artificial Neural Network is one set of algorithms used in machine learning for modeling the data using graphs of Neurons.
Ecosystem	Artificial Intelligence	Artificial Intelligence
Skills Required to learn	○ Probability and Statistics ○ Programming Skills ○ Data structures and Algorithms ○ Knowledge about machine learning frameworks ○ Big data and Hadoop	○ Probability and Statistics ○ Data modeling ○ Programming skills ○ Data structures and algorithms ○ Mathematics ○ Linear algebra and graph theory
Applied Areas	○ Health Care ○ Retail ○ E-commerce ○ Online recommendations ○ Tracking price changes ○ Better customer service and delivery systems	○ Finance ○ Health Care ○ Retailing ○ Machine learning ○ Artificial Intelligence ○ Stock Exchange Prediction
Examples	Siri, Google Maps and Google Search etc.	Image Recognition, Image Compression, and Search engines etc.

4. Conclusion

With the advent of modern electronics and computerized world, it was only natural way to try to harness this thinking process. The first step toward artificial neural networks came in 1943 when Warren McColloch neurophysiologist and a young mathematician, Walter Pitts, wrote a paper on how neurons might work. They modeled a simple neural network with electrical circuits. Neural networks use the processing of the brain as a basis to develop algorithms that can be used to model patterns and prediction problems. In our brain, Artificial Neural Network is an Information Processing Paradigm which is inspired by the way Biological Nervous Systems from the brain, process information. The key element of this paradigm is the structure of the information processing system, which is same as the neurons pass the information between neurons within the brain. It is composed of many numbers of highly interconnected processing elements (neurons) to solve specific problems. Artificial Neural Networks are essentially artificial neurons configured to carry out a specific task, like people, learn by examples. An Artificial Neural Network is configured for specific applications, such as pattern recognition, data classification, clustering, prediction, determining outliers through a learning process. Face recognition is discussing about the how the face can be recognized by using some algorithms. This is fact of ANNs as well and operates the massive computational elements in parallel to achieve high performance speed. This paper presented the Pros and Cons of Face Recognition in Artificial Neural Networks, Comparisons for Machine Learning and Artificial Neural Networks and Various Organizations are Using Face Recognition.

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