IFE JOURNAL OF INTEGRATED SCIENCE

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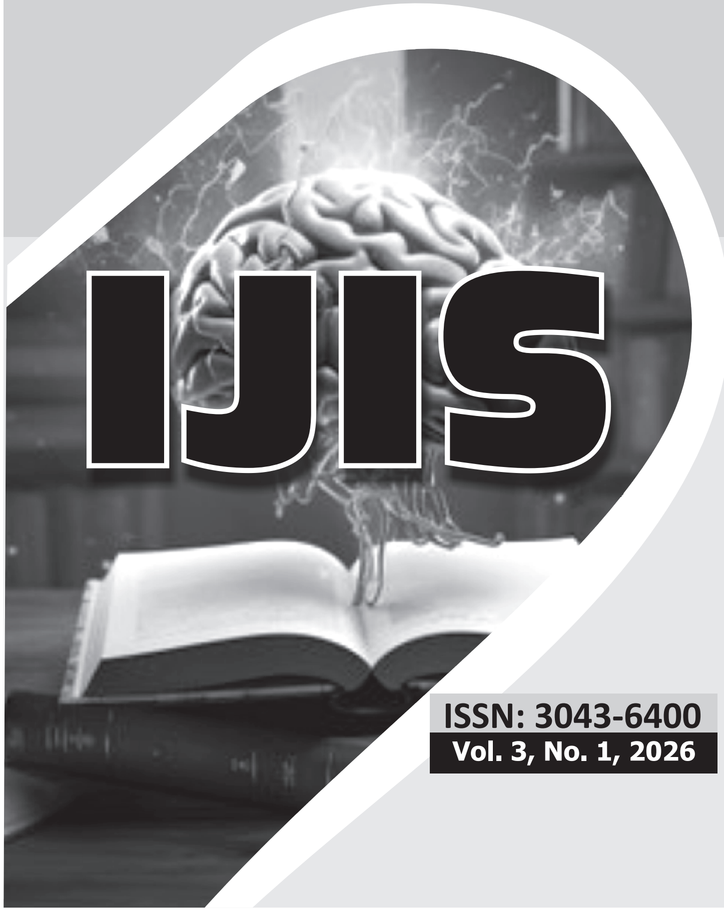

ISSN: 3043-6400
Vol. 3, No. 1, 2026

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NEURAL NETWORK AND ITS APPLICATION IN ENGINEERING IN NIGERIA

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NEURAL NETWORK AND ITS APPLICATION IN ENGINEERING IN NIGERIA

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Abstract

The paper examined the development and application of neural networks in engineering practice in Nigeria, emphasizing their role in intelligent control and automation. The objectives are to analyze how neural networks can model complex systems, improve predictive accuracy, and enhance decision-making across engineering disciplines. A descriptive analytical method was used, reviewing established neural network architectures such as feed-forward and recurrent models, their learning algorithms, and their implementation in real-world engineering systems. Findings show that neural networks effectively address problems involving non linearity, uncertainty, and data complexity. In electrical and power engineering, they support load forecasting, fault detection, and renewable energy optimization. In civil, mechanical, and petroleum engineering, neural models are applied to material prediction, process optimization, and reservoir simulation, respectively. They also facilitate intelligent traffic management and environmental monitoring within Nigeria's developing infrastructure. The study concluded that neural networks offer a powerful computational framework for engineering innovation, capable of self-learning and adaptation to complex environments. Despite challenges in scalability, verification, and interpretability, their continued advancement positions them as essential tools for future engineering systems and sustainable technological growth in Nigeria.

Introduction

Whenever we talk about neural network, we should more properly say "artificial neural networks" (ANNY, because that is what we mean most of the time. Artificial neural network are computers whose architecture is modeled after the brain. They typically consist of many hundreds of simple processing units which are wired together in a complex communication network. Each unit or node is a simplified model of a neutron which fires {sends off a new signal}if its receiver a sufficiency strong input signal from the other nodes to which it is connected.

An artificial neural network {ANNY}is an information processing paradigm that is inspired by the biological neural network that constitutes animal brains. {1}such system “learns" to perform tasks by considering examples, generally without being programmed with any task specific rules. For examples, in image recognition, they might learn to identify images that contain cats by analyzing examples that have been manually labeled as "cat" or no cat and using the results to identify cats in other images. They do this without any prior knowledge about cat, e.g. that they have fur, tails, whiskers and cat. Like faces instead, they automatically generate identifying characteristics from the leaning material that the process.

An ANN is based on a collection of a connected units or nodes called artificial neurons which loosely model the neutron in a biological brain. Each connection, like the synapse in a biological, can transmit a signal from one artificial neuron to another. An artificial that receives a signal can process it and then signal additional artificial neutron connected to it.

In common ANN implementations, the signal at a connection between artificial neutrons are a real number, and the output of each artificial neuron is computed by some non-linear function of the sum of its input. The connections between artificial neurons are called edges. Artificial neuron and edges typically have a weight that adjusts as learning proceeds. The weight increase or decrease the strength of the signal at a connection. Artificial neuron may have a threshold such that the signal is only sent if aggregate signal crosses that threshold. Typically, artificial kinds of transformations on their input signal starve from the first layer {their input layer}, possibly after traversing the layers multiple times.

The original goal of the ANN approach was to solve problems in the same way that a human brain would however, overtime, attention moved to performing specific tasks, loading to deviation from biology. ANN have been used on a variety of tasks. Including computer vision, speech recognition, machine translation, social filtering, playing boards and video games and medical diagnosis.

Purpose of the Study

The primary objective of this study is to examine the development and application of neural networks in engineering practice in Nigeria, with emphasis on their role in intelligent control, automation, and system optimization.

Specifically, the study seeks to:

a. examine the concept and architecture of artificial neural networks (ANNs) and how they emulate the structure and function of the human brain in information processing.
b. analyze various neural network models - such as feed-forward, recurrent, and multilayer perceptrons - and their significance in solving engineering problems.
c. investigate the applications of neural networks across major engineering disciplines in Nigeria, including electrical, civil, mechanical, petroleum, and environmental engineering.
d. assess the impact of neural networks on automation, predictive modeling, and decision-making processes in Nigerian industries.
e. identify the major challenges and limitations associated with neural network implementation, including issues of scalability, testing, verification, and interpretability.

Historical Background

Neural network simulation appears to be a recent development. However, this field was established before the advent of computer and has survived at least one major setback and several eras. Many important advances have been boosted by the use of in expensive computer emulations. Following an initial period of enthusiasm, the field survived a period of frustration and disrepute. During this period when funding and professional support was minimal important advances were made by relatively few researchers these pioneers were able to develop convincing technology which supposed the limitation identified by minsky and papert. Minsky and papert, published a book {in 1967}I they summed up a general feeling of frustration against neural [network] among researchers, and was thus accepted by most without further analysis, currently, the neural network field enjoy a resurgence of interest and a corresponding increase in funding. The first artificial neuron was produced I 1945 by the neurophysiologist warren mc McCelloch and the Logic Walter pits. But the technology available at that time did not allow them to do too much.

Why use Neural Network

Neural network with their remarkable ability to derived meaning from complicated or imprecise data can, be used to extract pattern and detect trends that are too complex to be noticed by either human or other computer techniques. A trained neural network can be through of as an "expert " in the expert can then be used to provide projections given new situation of interest and answer "what IP" questions other advantages include:

Adaptive learning: an ability to learn how to do task based on the data given for training or initial experience

Self-organization: an ANN can create its own organization or representation of the information its receive during learning time

Real time operation: ANN computation maybe carried out in parallel and special hardware devices are being designed and manufactured which take advantage of this capability fault to Lerance via redundant information coding: partial destruction of a network lead to the corresponding degration of performance. However, some network capabilities may be retained even with major network damage

Neural Networks Versus Coventional Computers

Neural networks take a different approach to problem solving than conventional computers. Conventional computers use an instruction in order to solve problem. Unless the specific steps that the computer need to follow are know the computer cannot solve the problem. They restrict the problem-solving capability problem. They restrict the problem-solving capability of conventional computers to problems that we already understand and know how to solve. But computers would be so much more useful if they could do things that we don't exactly know how to do. Neural networks process information in a similar way the human brain does. The network is composed of a large number of highly interconnected processing elements (neurons) working in parallel to solve a specific problem. Neural networks learn by example must be selected carefully otherwise useful time is wasted or even worse the network finds out how to solve the problem by itself its operation can be unpredictable.

On the other hand, conventional computers use a cognitive approach to problem solving, the way the problem is to solved must be known and stated in small ambiguous instructions. These instructions are then converted to a high-level language program and then into the machine code that the computer can understand these machines or hardware faults.

Neural networks and conventional algorithm computers are not in competition but complement each other. These tasks are more suited to an algorithmic approach like arithmetic operations and tasks that are more suited to neural networks. Even more a large number of tasks, require systems that use a combination of the two approaches (normally a conventional computer is used to supervise the neural network in order to perform at maximum efficiency).

Human and Artificial Neurones Investigating the Similarities

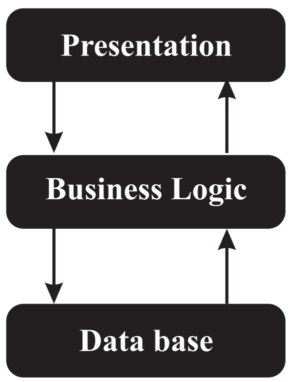
Much is still unknown about the brain trains itself to process information, so theories abound. In the human brain, a typical neuron collects signals from others through a host of fine structures called dendrites. The neuron sends out spikes of electrical activity through a long, thin stand known as axon, which splits into thousands of branches. At the end of each branch, a structure called a synapse converts the activity from the axon into electrical effects that inhibit or excite activity in the connected neurons. When a neuron receives excitatory input that is sufficiently large compared with its inhibitory input, it sends a spike of electrical activity down its axon.

From Human Neurones to Artificial Neurones

We conduct these neural networks by first trying to deduce the essential feature of neurones and their interconnections. We then typically program a computer to simulate these features, however because our knowledge of neurones is incomplete and computing power is limited, our models are necessarily gross idea Lisations of real networks of neurones.

Architecture of Neural Network

Architecture of Artificial Neural

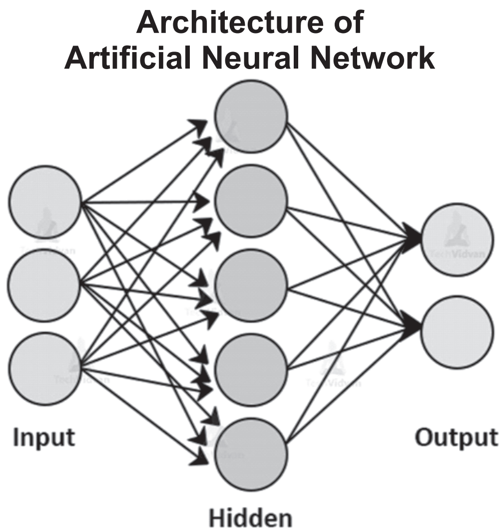


Neural Network is a series of algorithms that are trying to mimic the human brain and find the relationship between the sets of data. It is being use in various use-cases like in regression, classification, Image Recognition and many more.

As we have talked above that neural networks tries to mimic the human brain then there might be the difference as well as the similarity between them.

Some major differences between them are biological neural network does parallel processing whereas the Artificial neural network does series processing also in the former one processing is slower (in millisecond) while in the latter one processing is faster (in a nanosecond).

Architecture of ANN



Neural networks are of only different in their learning process but also different in their structures or topology. Bose (1916) has broadly classified neural networks into recurrent (involving feedback) and non-recurrent (without feedback) ones. In a little more detail, Haykin has divided the networks architectures into the following three classes:

Feed-forward Networks

Feed-forward ANNs about signals to travel on way only: from input to output, there is no feedback (loops) i.e. the output of any layer does not affect that same layer. Feed-forward ANNs tend to be straight forward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organization is also referred to as bottom up or top-down. Sin-ne-layer perceptions are classes of feed forward networks.

Single-layer Perceptrons (Feed Forward Networks)

The simple-layer perceptron was among the first and simplest learning machines that are train-able. In Haykin's book (1999), perception denotes the class of two-layer feed forward networks.

Whose first-layer units have fixed function with fixed connection weights from the inputs and
Whose connection weights linking the first layer to the second layer of outputs are learnable.

Multi-layer Perceptrons (Feed-forward Networks)
Multi-layer feed-forward structures are characterized by directed layered graphs and are the generalization of those earlier single layer structures (Bose, 1996).

Structure and Features of MLP
Multi-layer perceptron (MLP) networks are feed-forward nets with one or more layers of nodes between the input and output nodes. The structure of an unadorned multilayer perceptron network is shown in

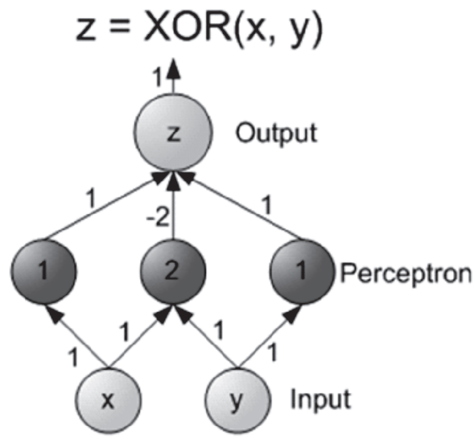


Figure 1: Feed-forward multilayer perceptron architecture (PANDYA & MACY, 1996, P.74)

The capabilities of multilayers perception stem from the non-linearity's used with nodes.

Feedback Networks
Feed networks (figure 1) can have signals traveling in both directions by introducing loops in the network. Feedback architectures are also received to as interactive or recurrent, although the latter term is often

used to denote, feedback connections in single-layer organizations. In the neural network Literature, neural networks with one or more feedback loops are referral to as recurrent networks. A recurrent network distinguishes itself from a feed forward neural network in that it has at least one feedback loop

Neural Networks and its Applications in Engineering

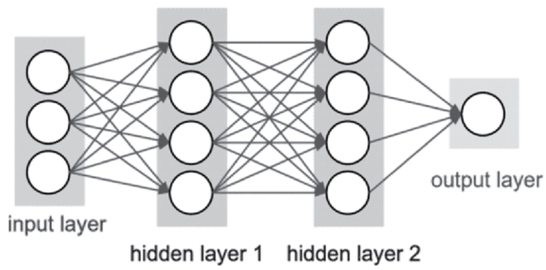


Figure 2. An example of a simple feed forward network (Stregiou and siganos, 1996)

Network Layers

The commonest type of artificial neural network consists of three groups, or layers, of units: a layer of "input" units is connected to a layer of "hidden" units, which is connected to a layer of "output" units.gb the activity of the input units represents the raw information that is fed into the network.

The behavior of the output units depends on the activity of the hidden units and the weight between the hidden and output units.

Training a Neural Network

For the most part, a network is trained by changing the weighs the connection between nodes. These weighs can be randomly chosen or individually chosen. Usually, a computer program randomly generates values for connection weights then network is given an input, and it is all-lowed to process the information through its nodes to produce an output.

The Learning Process

The memorization of patterns and the subsequent of the network can

be categorized into two general paradigms. Associative mapping in which the network learn to produce a particular pattern is applied on the set of input units.
Auto-association: An input pattern is associated with itself and the states of input and output units coincide.

The Back-propagation Algorithm
In order to train neural network to perform some task, we must adjust the weights of each units in such a way that the error between the desired output and the actual output is reduced this process requires that the neural network compute the error derivative of the weights (EW). In other words, it must calculate how the error changed as each weight is increased or decreased slightly.

Applications of Neural Networks in Engineering
A Simple Neuron
An artificial neuron is a device with many inputs and output (Figures 3). The neuron has two modes of operation; the training to fire (or not) for particular input patterns. In the using mode, when a taught input pattern is detected as the input, its associated output becomes the current output if the input pattern does not belong in the taught list of input patterns, the firing rulers used to determine whether to fire or not.

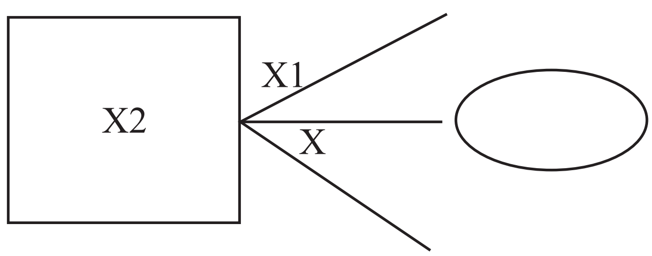


Figure 3. A simple Neuron

Firing Rules
The firing rule is an important concept in neural networks and accounts for their high flexibility. A firing rule determines how one calculated whether a neuron should fire for any input pattern. It relates to all the input patterns not only the ones on which the node

was trained. The firing rule gives the neuron a sense of similarity and enables it to respond 'sensibly' to patterns not seen during training.

Applications of Neural Networks In Engineering in Nigeria

1. **Electrical and Power Engineering**: Nigeria's power sector faces challenges such as unstable supply, equipment faults, and demand fluctuations. Neural networks can be applied for:

- **Load forecasting** to predict energy demand and optimize grid operations.
- **Fault detection and diagnosis** in transmission lines and transformers to reduce blackouts.
- **Renewable energy optimization**, especially for solar and wind integration into the grid.

2. **Civil and Structural Engineering**: Neural networks can aid in:

- Predicting material strength and durability in construction projects.
- Analyzing structural stability of buildings and bridges under different load conditions.
- Optimizing road construction and predicting traffic congestion, which is crucial in Nigerian cities like Lagos and Abuja.

3. **Mechanical and Manufacturing Engineering**: In industries such as automobile assembly, cement, and steel manufacturing, neural networks can be used for:

- **Predictive maintenance** of machinery, reducing downtime and costs.
- **Process optimization** in production lines, ensuring higher quality output.
- **Robotics control systems**, allowing more precise and intelligent automation.

4. **Petroleum and Chemical Engineering**: Given Nigeria's dependence on oil and gas, neural networks are useful for:

- **Reservoir characterization and simulation**, improving exploration and drilling accuracy.

- **Predicting equipment failures** in refineries to minimize losses.
- **Process optimization** in chemical plants to improve efficiency and reduce waste.

5. **Transportation Engineering**: With growing urbanization, traffic congestion is a major challenge. Neural networks can help in:

- Designing **intelligent transport systems (ITS)** for traffic signal control and route optimization.
- **Accident prediction and prevention** through real-time data analysis.
- Enhancing logistics and supply chain networks for improved goods distribution.

6. **Environmental Engineering**: Neural networks can support environmental monitoring and sustainability efforts, such as:

- Predicting air and water pollution levels in industrial areas.
- Modeling climate impacts on infrastructure and agriculture.
- Waste management optimization, crucial for urban centers like Lagos.

Neural Networks in Practice

Neural networks have broad applicability to real world business problem. Infact, they have already been successfully applied in many industries. Since neural networks are best at identifying patterns or trends in data, they are well suited for prediction or forecasting needs including:

- Sales forecasting
- Industrial process control
- Customer research
- Data validation
- Risk management

ANN are also used in the following specific paradigms: recognition of speaks in communication; diagnosis of hepatitis; undersea mine detection; texture analysis; three-dimensional object recognition, hand-written word recognition and facial recognition.

Typical applications of hardware NNWS are:

OCR (Optical Character Recognition):
Here, NN was employed in OCR by care incorporation which recorded about 3 million dollars profit on 55 million dollar revenue in 1997. The adaptive solutions image link OCR subsystem captures the special high performance hardware required for high through put these days a purchase of a new scanner typically includes a commercial OCR program ligature Ltd also has an OCR-on-a-chip example which illustrates a cheap dedicated chip for consumer products.

Data Mining: A company named HNC made about 23 million Dollars profit on 110 million dollar revenue in 1997, on their product called falcon. "falcon is a neutral network based system that examines transaction, cardholder, and merchant data to detect a wide range of credit card fraud.

Voice Recognition:
Examples are the sensory Inc. RSC microcontrollers and ASSP speech recognition specific chips.
Traffic monitoring: An example is the Nestor traffic vision system.
High Energy Physics: An Example is an online data filter built by a group at the mazePlanck institute for the HII Electron-proton collider experiment in the Hamburg using Adaptive Solution (NAPS Boards. However, most NNW applications today are still run with the conventional software simulation on PC'S and workstations with no special hardware add-ons.

Neural Networks in Control Engineering
The ever-increasing technological demands of our modern society requires innovative approaches to high demanding control problems. Artificial neural networks with their massive parallelism and learning capabilities offer the promise of better solutions, at least to some problems by now, the control community has heard of neural networks and wonders if these networks can be used to provide better

control solutions to old problems or perhaps solutions to control problems that have withstood our best efforts.

Control System Applications

Neural networks have been applied very successfully in the identification and control of dynamic system. The universal approximation capabilities of the multi-layer perception have made it a popular choice for modeling nonlinear systems and for implementing general purpose nonlinear controllers. For the purpose of this work we will look at neural networks as functions approximators. As shown in figure 4, we have some unknown function that we wish to approximate. We want to adjust the parameters to the network so that it will produce the same response as the unknown function, if the same input is applied to both system. For our applications the unknown function may correspond to a system we are trying to control, in which case the neural network will be the Awodele and Jegede identified plant model. The unknown function could also represent the inverse of a system we are trying to control in which case the neural network can be used to implement the controller.

Fixed Stabilizing Controllers

Fixed stabilizing controllers (see figures) have been proposed in (Kawato, 1990). This scheme has been applied to the control of robot arm trajectory, where a proportional controller with gain was used as the stabilizing feedback controller. We can see that the total input that enters the plant is the sum of the feedback control signal and the feed forward control as an error signal. As the ENN training advance, that input will converge to zero. The neural network controller will learn to take over from the feedback controller. The advantage of this architecture is that we can start has not been adequately trained. We have selected one type of network the multilayer perception. We have demonstrated the capabilities of this network for function approximation and have described how it can be trained to approximate specific functions. We then presented control architecture which use neural network function approximators as basic building blocks. Control engineering also involves robotics were intelligent.

Control is the discipline that implements intelligent machines (MS) to perform anthropomorphic tasks with minimum supervision and interaction with a human operator (Jegede, Awodele, Ajayi and Ndong, 2007).

Agricultural Control System Engineering

Control and management of agricultural machinery offers many opportunities for application of general purpose empirical models. The nature of agricultural machines creates the need for modeling systems that are robot, noise tolerant, adaptable for multiple uses, and are extensible. Artificial Neural Networks (ANNS) have these characteristics and are attractive for use in control and modeling in agricultural machine`

A sensor was fabricated to detect color on the surface of the ground in a 75 by 50cm wide image. Three color bands: green, red and near infra-red were sensed. The signals from the senser were digitized with a 68HCII based controller using the on-chip 8-bit A/D converter the 68HSII based computer was also to activate a solid state switch that energized a solenoid value in the spray nozzle. The intent of control in the system was to sense the presence of a weed by color and to activate the nozzle to spray the plant at the point in time that the plus the time required for the fluid to reach the ground once it emerges from the nozzle was insignificant, the sensor and nozzle could be located together. Agricultural sprayers based on optical sensing and control of spray nozzle activation currently exists on the market.

Weed Identification

Zhang Yanyi, and El-Faki (1994) reported the use of ANNS to process color images of weeds in a winter-wheat environment with the objective of being able to distinguish between weeds and other components of the image they were particularly interested in detecting weeds with reddish stems. An ANN was also developed to allow color patterns to be recognized in an agricultural weed sprayer application by stone (1994).

Neural Networks in Electrical Engineering

Artificial Neural Network (ANN) is currently a "hot" research in electrical engineering the model used to simulate artificial neural networks is based on the biological nerve cell or neuron shown in figure 7. Electrical signals arising from impulses from our receptor organs (e.g. eyes, ears) are carried into neuron on dendrites.

Signal Classification With Perception

A problem of particular interest to electrical engineers is that of signal detection, particularly in a noisy environment method such as filtering and signal averting have used successfully.

Neural Networks and its Application in Civil Engineering

Neural Network have gained a broad in civil engineering problems. They are used as an alternative to statistical and optimization methods as well as in combination with numerical simulation systems. Application areas in Civil Engineering are e.g. forecasting, water management, control and decision support systems.

Limitations of Neural Networks

The major issues of concern today are the scalability problem, testing, verification and integration of neural network systems into the modern environment neural network programs sometimes become unstable when applied to larger problems.

The defense, nuclear and space industries are concerned about the issue of testing and verification the mathematical theories used to guarantee the performance of an applied neural network are still under development the solution for the time being may be to train and test these intelligent systems much as we do for humans. Also there are some more practical problems like: The operational problem encountered when attempting to simulate the parallelism of neural networks instability to explain any results that they obtain network functions as "black boxes" whose of operation are completely unknown.

Summary

Engineering applications of neural networks cites different applications in the major engineering disciplines and presents some recent applications investigated in the author's laboratory introduction neural are computation models of the brain. There are over 50 different neural network models, same based more closely on current understanding of the brain operation than others. However, in general neural networks all have two of the brain's important characteristics: a parallel and distributed and an ability to learn.

Conclusion

Prediction for the future rests on some sort of evidence or established trend which, with extrapolation, clearly takes us into a new realm-neural networks will fascinate user-specific system for education, information processing, entertainment genetic engineering, neurology and psychology. Programs could be developed with require feedback from the user in order to be effective but simple and "passive" sensors (e.g fingertip sensors, gloves or wrist and to sense pulse , blood pressure, skin ionization and so on), could provide effective feedback into a neural control system. NN's ability to learn by example aspect of neural networks is the possibility that someday 'conscious' networks might be produced.

Recommendations

Based on the findings of this study, the following recommendations are made to enhance the adoption and effectiveness of neural network applications in Nigerian engineering systems:

1. **Integration into Engineering Education:**
   Tertiary institutions in Nigeria should integrate artificial intelligence and neural network courses into engineering curricula to equip students with modern computational and problem-solving skills.

2. **Increased Research and Development (R&D):**
   The government and private sectors should increase funding for R&D in artificial neural networks to foster innovation and indigenous technological solutions tailored to Nigeria's engineering challenges.

3. **Industrial Adoption and Automation:**
   Engineering industries should embrace neural network

technologies for predictive maintenance, fault detection, and process optimization to enhance efficiency and reduce downtime.

4. **Academia–Industry Collaboration:**
Strategic collaboration should be established between universities, polytechnics, and industries to facilitate practical research and application of neural networks in solving real-world engineering problems.

5. **Professional Training and Capacity Building:**
Workshops, seminars, and professional development programs should be organized regularly to train engineers, technicians, and IT professionals in neural network modeling and applications.

6. **Development of Localized ANN Tools:** Nigerian engineers and software developers should design and deploy localized neural network tools that address specific industrial and environmental conditions within the country.

7. **Government Policy and Regulation:**
The Nigerian government should create policies, incentives, and regulatory frameworks that encourage the adoption of artificial intelligence and neural network technologies in key engineering sectors such as energy, construction, and transportation.

8. **Addressing Implementation Challenges:**
Stakeholders should focus on solving issues related to neural network scalability, verification, and transparency by developing standardized testing protocols and reliable system evaluation methods.

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