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Testing Neural Network (NN) algorithms implemented in MATLAB for the study of rainfall distribution patterns at different locations in Nigeria

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Abstract

In Nigeria, accurate information concerning rainfall distribution is generally difficult to obtain because it is a discontinuous quantity. Therefore, special tools and equipment are required for its recording and interpretation. This has made information dissemination regarding rainfall distribution across different locations in Nigeria difficult. The scenario has made everyone sorely dependent on the Nigeria Meteorological Agency (NiMet) as the only source of recording and interpreting rainfall distribution. Rainfall distributed at different locations in Nigeria at the same time and season for a particular year is not even. Therefore, it is uncertain for one to conclude that the rainfall distribution pattern at one location is or will be the same or different at another location at a particular time and season of the year. Therefore, the objective of this work is to test neural network (NN) algorithms implemented in MATLAB for the study of rainfall distribution patterns at different locations in Nigeria using satellite-based data obtained from The European Centre for Medium-Range Weather Forecasting (ECMWF) to have alternative methods of interpreting rainfall data in Nigeria. After data conversion, the designed neural network algorithms implemented in MATLAB were adopted to contour daily rainfall incidences in all the locations for the years of study. The result of the study showed that locations with latitude closer to 4^o, received the highest amount of rainfall distributions and locations with latitude farther to 4^o, received the lowest amount of rainfall distributions within the same years of the study. The results also showed that rainfall distribution patterns can be interpreted using NN implemented algorithms in MATLAB and they vary at different locations in Nigeria. Therefore, NN algorithms implemented in MATLAB may serve as another method for fast and reliable interpretation of rainfall distribution recorded data at any chosen location.

Keywords: Neural network; Algorithms; MATLAB; Rainfall distribution

1. Introduction

Neural network algorithms in MATLAB are a set of codes that can be combined together to compare relationships in a dataset by possibly mimicking the way the human brain works. Based on that, neural network algorithms resemble the human neuron in the brain. In most cases, modelling, forecasting, etc, may be carried out with the help of neural network algorithms.

Rainfall occurs when condensed water vapour masses in the atmosphere fall back to the earth, in the form of raindrops resulting from the complex interactions that exist in the Earth-atmosphere environment. Consequently, it is being driven by the condensation of air masses through upward movement in the atmosphere. Rainfall to greater extent in Nigeria has been of immense importance to economic development and sustainability. However, extreme amounts or no rainfall incidence for a long period at a particular location may consequently cause many hazards of various types and variable magnitudes. Obviously, rainfall is the most critical and key parameter of interest in both atmospheric and

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hydrological cycles. Generally, rainfall exhibits two different distribution patterns in Nigeria; spatial and temporal distribution patterns and invariably has indisputably affected agricultural production, water supply management, and has equally resulted to environmental hazards and degradation on many occasions.

Nigeria, which has border with different geographical landscapes, has had different rainfall distribution, patterns over the years at different locations within the country and at different times. In the coastal and southern flanks of the country, rainfall usually begins in late February or early March as a humid Atlantic air mass described as the southwestern Monsoon and is injected into the country through the Atlantic Ocean. High magnitude winds and heavy storms usually foretell the commencement of rainfall in Nigeria. The heavy storms and rainfall are mainly scattered in the northern part of the country, especially in the dry years when some areas experience dry weather. Rainfall distribution farther north usually commenced probably by June or July and sometimes extends to early August where the peaks of the rainfall are in most cases experienced almost throughout northern Nigeria. This is consequent upon the convective air masses coming from the Atlantic Ocean that eventually dominate the entire country.

From April to May, rainfall distribution mainly dominates most areas around the south. The southern part of Nigeria is marked for heavy rainfall distribution due to the location of the region near the equatorial belt and the Atlantic Ocean, which makes it prone to heavy storms and in most cases is convective in nature. In Nigeria, impromptu rainfall, heavy rainfall, no rainfall and moderate rainfall distribution has caused a lot of damage to both life and properties of the citizens in the form of flood, drought, etc; while on the other hand, it has invariably enhanced agricultural productivity and water resources management.

The study in various regions of Africa shows that rainfall has periodic tendencies [1]. This is because of their possible changes in climatic conditions within the earth-atmospheric environment [1]. In the work carried out by Adefolalu on the study of rainfall patterns in Nigeria for a period of 40 years (1940–1980), he observed that the areas located north of 8^{o}N latitude receive an annual rainfall distribution of about 90% to 100% from April to October [2]. In their separate study, Adejowun, Balogun and Adejowun, discovered that rainfall distribution can be a function of space and the amount of rainfall received within a given location at a given time [3]. They opined that rainfall, in a nutshell, is not evenly distributed over a given space and time within a given year.

Rainfall and temperature are regarded as the most important climatic parameters linking to the impacts of the change in climate. Rainfall is considered as the most valuable factor in the choice and the type of crop change. The frequency and intensity of rainfall have been associated with the heavy down fall [4]. Several researches have indicated that there are variations in the spatial and temporal distribution of rainfall in different areas [5]. Therefore, the global-scale observations of historical climate are rendered non-viable for regional-scale planning of water resources or agricultural activities [6, 7].

In so many cases, interpreting rainfall incidences over different locations in Nigeria for possible forecast has been a major task confronting atmospheric researchers and meteorologists due to the lack of availability of specialized tools needed to handle the pool of rainfall data. This is mostly because rainfall is a discontinuous quantity and thus, special tools and approaches are required to handle its datasets to minimize the errors that may be associated with its results, as they may lead to endemic problems if wrongly interpreted. This has made it difficult for many people to get information regarding rainfall past, present, and future status since they cannot afford to get rainfall distribution recording and interpreting equipment. This has made the populace in Nigeria sorely dependent on the Nigerian Meteorological Agency (NiMet) as the only source of obtaining information regarding rainfall and other weather conditions records and interpretation for a given period in a particular location. Therefore, the objective of this work is to test neural network (NN) implemented algorithms in MATLAB for the study of rainfall distribution patterns at different locations in Nigeria using satellite-based data. The neural network (NN) implemented algorithms can improvise another method that may be used to study and interpret rainfall incidences, other than depending only on the information obtained from NiMet.

2. Material and methods

The daily data from 1983-2013 (30 years) used in this work is made up of a satellite (Reanalysis-Interim) dataset that is comprised of rainfall recorded data obtained from the European Centre for Medium-Range Weather Forecasting (ECMWF) and is jointly managed by National Center for Atmospheric Research data support section. The spatial resolution of ECWMF datasets is 0.125° latitude by 0.125° longitude (spectral truncation T159), and they extend from 1979 through the present. The Panoply and the Ferret software packages, sourced from the Goddard Institute for Space Studies (GISS), and the National Oceanic and Atmospheric Administration (NOAA), respectively, were equally used for data conversion. Four (4) data coordinate locations in Nigeria as shown in table 1, which cover the spatial location of different states, were used in this work.

Table 1 Locations used with their coordinates and elevation points over Nigeria

S/N	Location	State	Latitude1	Longitude1	Elevation(m)
1	Abuja	FCT	9.01	7.26	344
2	Calabar	Cross River	4.98	8.35	63
3	Enugu	Enugu	6.47	7.56	137
4	Mallam Amin	Kano	12.05	8.52	481

After data downscaling and conversion, neural network implemented algorithms designed in MATLAB were adopted to contour the daily rainfall incidences in all the locations for the years of study. During contouring of rainfall data, daily changes in rainfall amount distributions were investigated using the designed algorithms for each location across the years of study.

3. Results

The result of contour plots of rainfall distribution patterns obtained at Abuja, Calabar, Enugu and Mallam Amin (Kano) in Nigeria using the designed NN algorithm implemented in MATLAB are shown below

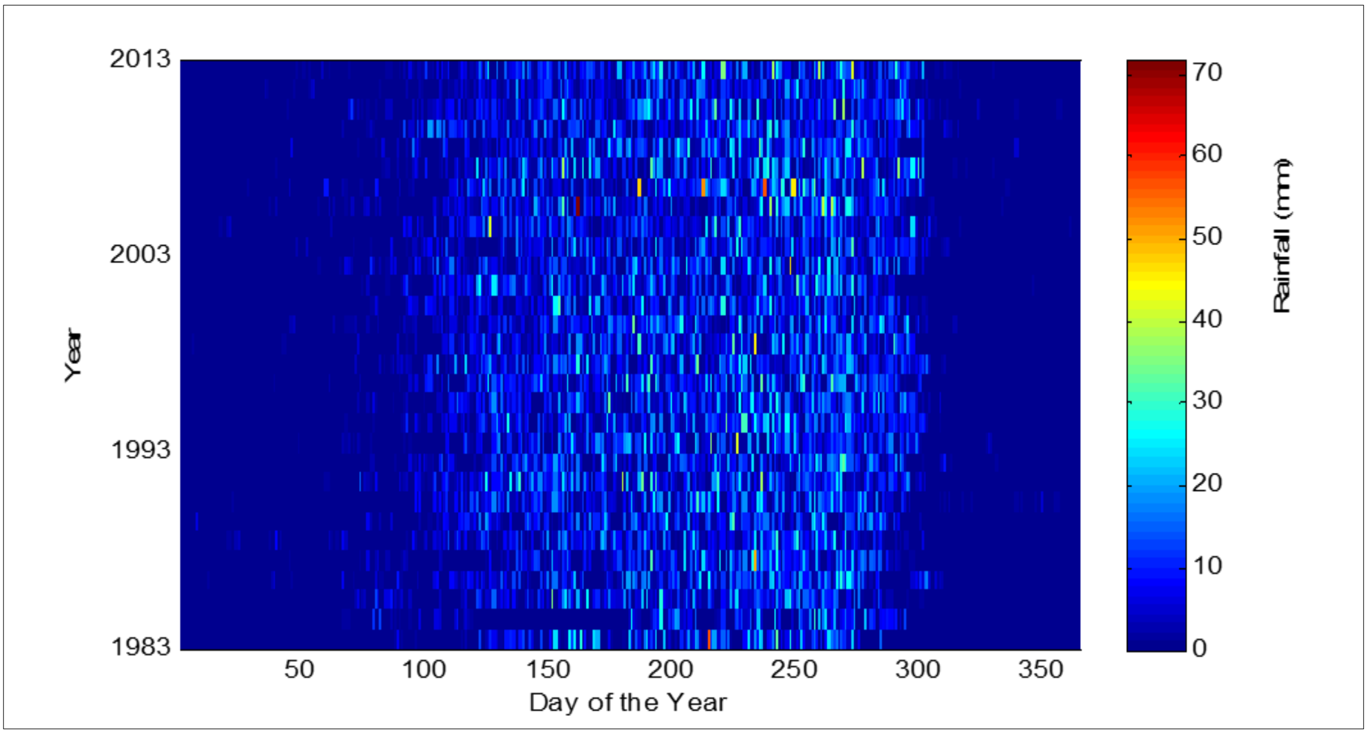

Figure 1 Rainfall distribution patterns at Abuja from 1983 to 2013 in Nigeria

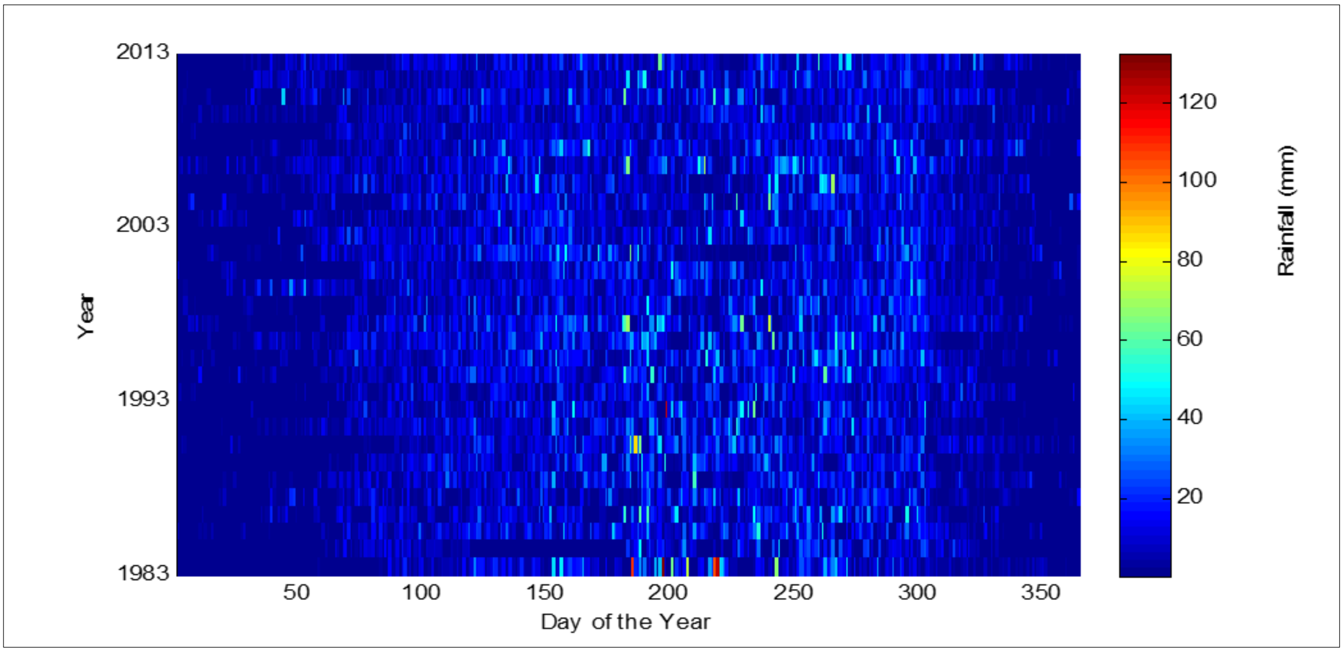

Figure 2 Rainfall distribution patterns at Calabar from 1983 to 2013 in Nigeria

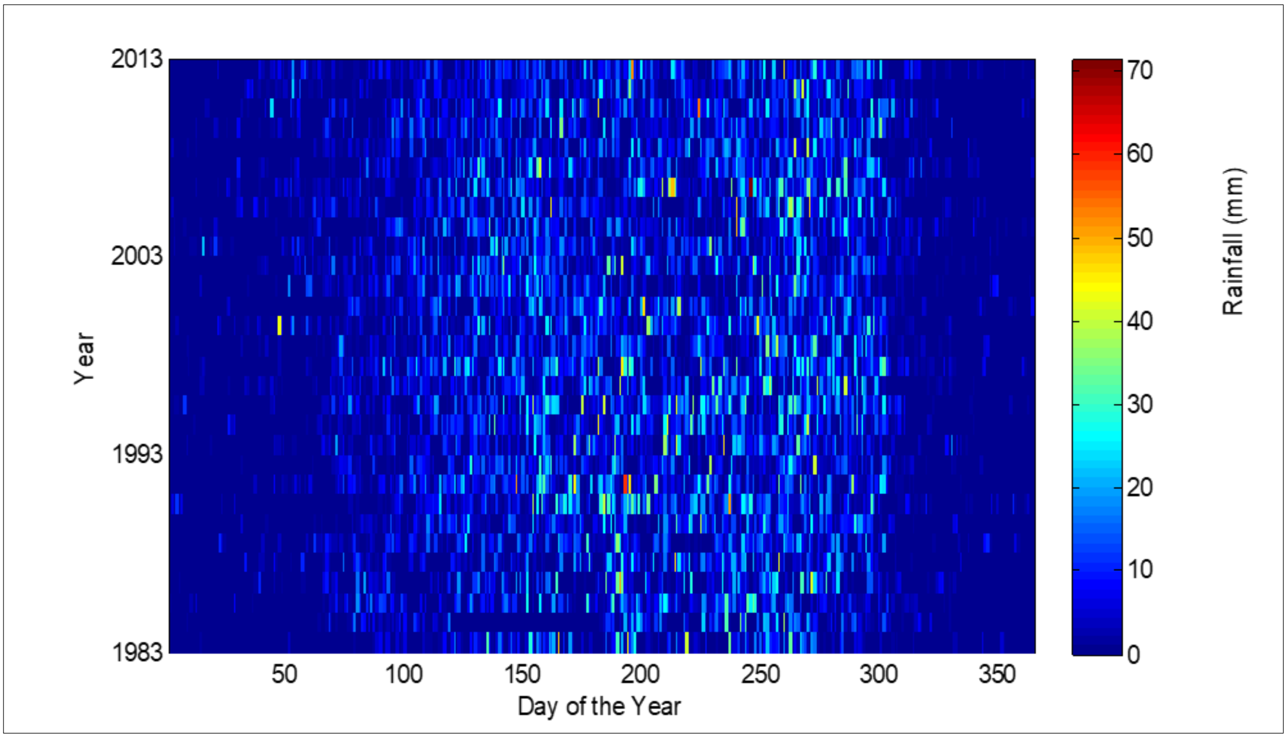

Figure 3 Rainfall distribution patterns at Enugu from 1983 to 2013 in Nigeria

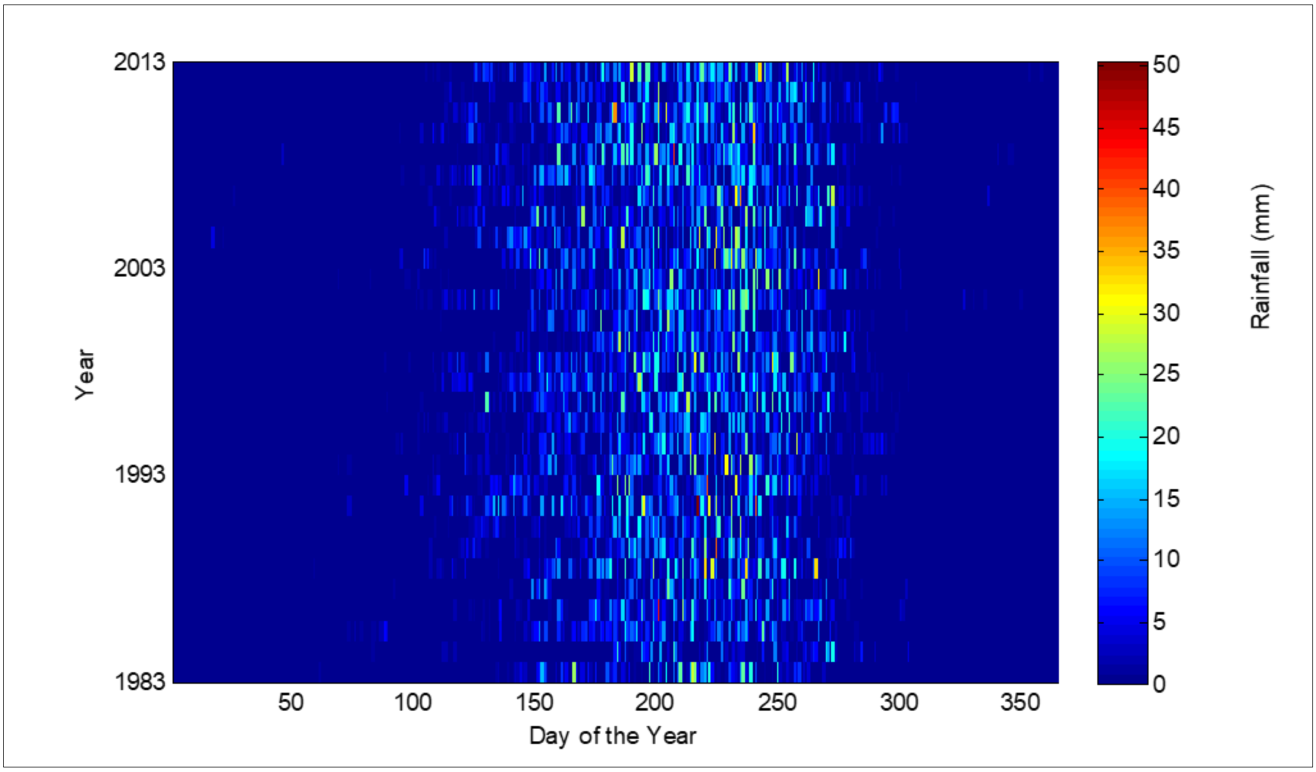

Figure 4 Rainfall distribution patterns at Mallam Amin, Kano from 1983 to 2013 in Nigeria

4. Discussions

Abuja (Fig. 1) experienced sparse or no rainfall distribution from day 1 to 100 (January–April) and between days 300 and 365 (November–December) in 2013.This was seen to be true in almost all the years of study (1983–2013). However, rainfall distributions were more densely observed from day 101 to 299 (May-October) in all the years (1983–2013), with the maximum rainfall amount of 70 mm per day recorded in 1983 and 2006 respectively. This suggests that from day 1 to 100 as well as from day 300 to 365 (January-April and November-December) marking the dry season periods, there were little or no rainfall distributions across the days. In addition, from day 101 to 299 (May-October) marking the rainy season, there were concurrent distributions of rainfall across the days at Abuja for all the years (1983–2013). This result suggests that rainfall distributions were more intense during the rainy season than during the dry season at Abuja for the years of study. This high intensity of rainfall during the rainy season may be due to the influence of some environmental factors such as geographical location, relief, and proximity to rainfall generation sources, among others.

From the results, Calabar (Fig. 2) and Enugu (Fig. 3), have sparsely or no rainfall distributions from day 1 to around day 45 (January to February) and from day 351 to 365 (November to December), representing the dry seasons for the same year of study. Conversely, between days 51 and 350 (March to October), there were regular and consistent rainfall distributions across the days for most of the locations, with a short break in rainfall often referred to as the "August break" sported between days 200 and 250 in some of the years of study. The observations here are an indication that rainfall commenced much earlier and has stopped lately in all the locations in the years of study. Consequent upon that, Calabar has the highest amount of rainfall (120 mm) distribution per day recorded in 1983. The observation may be because of the influence of the tropical monsoon climate change, proximity of the locations to the Atlantic Ocean as well as to the equatorial belt, which made them more prone to early and heavy amounts of rainfall distribution for most days in the years of study.

At Mallam Amin Kano (Fig. 4), few rainfall distributions were spotted on early days (days 1–60), representing January–February in some years. However, from day 45 to 289 (February to April), there were sparse rainfall distributions in all the years (1983–2013) of study. Mallam Amin Kano, as observed from Fig. 4, witnessed heavy rainfall from Day 101 to 299, which fell within May and October. Rainfall distributions were not observed from Day 300 to 365 (November - December) in all the years. This result at Mallam Amin Kano suggests that the only period it experiences a total dry season is between November and December. There is an equally remarkable dry season between January and April in some of the years of study. However, the area experiences more intense rainy periods from May to October in almost all the years of study.

In general, inferring from the observation of rainfall distribution patterns and, characteristics at different locations, as obtained using the NN algorithm implemented in MATLAB it is alleged that rainfall distributions for the periods of the study do not maintain the same pattern at various locations at the same time because of geographical location, among others. Thus, rainfall distributions have peculiar characteristics associated with them for all the locations in all the years of the study. This suggests that in some locations, rainfall distributions have a relatively higher amount at the same period and time, while in some other locations, rainfall distributions have a relatively lower amount at the same period and time for the same year, implying that, rainfall across each location is not evenly distributed. Similarly, some locations received the highest amount of rainfall and their distributions were so eminent throughout the year while others received the lowest amount of rainfall and their distributions were just sudden or for a limited time for the same year.

5. Conclusion

This work has shown that NN algorithm designed and implemented in MATLAB can serve a good purpose for rainfall distribution pattern's study and interpretation for any selected location within a given period. From the work, at various locations in Nigeria, rainfall distributions do not follow the same pattern at the same time and season, and are quite dependent on geographical locations, as well as proximity to the equatorial belt and rain generating sources. Consequently, the study observed that locations closer to the Atlantic ocean and the equatorial belt (locations with latitude closer to 4^o) received the highest amount of rainfall distributions and locations farther away from the Atlantic ocean and the equatorial belt (locations with latitude farther to 4^o) received the lowest amount of rainfall distributions within the same years of study.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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