Applications of Artificial Neural Networks in Aerial and Satellite Imagery Analysis: A Case Study on the Natural Terrain of South Sinai

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Summary:

Neural networks are considered powerful and effective tools in geographic studies, with numerous applications in image classification, phenomenon modeling, spatial prediction, and change detection. A study has demonstrated successful use of neural networks in analyzing aerial and satellite images in studying the southern Sinai Peninsula.

This study addresses geomorphological and geological analysis of southern Sinai's terrain using artificial intelligence and artificial neural networks. The research aims to explore the role of neural networks in classifying and analyzing aerial and satellite images to determine geomorphological phenomena such as land elevations and natural terrain changes. The study focuses on applying Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) in analyzing geographical and geological data, as well as classifying unstructured geomorphological data and using machine learning to extract patterns and relationships. Additionally, it analyzes natural terrains to identify areas of high elevations and rugged terrains.

The study utilizes neural networks to predict future changes in natural terrains, such as coastline shifts, rock mass movements, and the formation of new valleys due to climatic or geological factors. It includes gathering and analyzing historical and current data on natural changes in the southern Sinai region using remote sensing techniques and Geographic Information Systems. The study aims to provide information to aid in urban planning, environmental protection, and natural resource exploration based on geomorphological data analysis and predictions of natural changes.

Various methodologies are employed in the study, including data collection from satellite images and geological maps analyzed using remote sensing and GIS. Directed classification techniques such as nearest neighbor algorithms and Artificial Neural Networks (ANNs) are used for data classification, while undirected classification methods like K-Means and ISODATA are used for clustering data based on inherent characteristics. Convolutional Neural Networks (CNNs) are designed, trained, and evaluated using metrics such as accuracy, sensitivity, and specificity. Support Vector Machines (SVMs) are implemented for classification and feature extraction. Programming tools such as Python, TensorFlow, Keras, GIS software like ArcGIS, and remote sensing tools like Erdas Imagine are utilized for data analysis. Advanced artificial intelligence applications such as Copilot, Claude.ai, and Gemini 1.5 Pro are also used for data analysis and map classification. Data is processed and converted into suitable formats for neural network training, with multi-layer neural network structures created and data divided into training, testing, and validation sets to improve the model.

The study's results highlight the effectiveness of artificial neural networks in analyzing aerial and satellite images, successfully predicting geomorphological changes using Convolutional Neural Networks, enhancing geological map accuracy, analyzing climate data for future predictions, improving water resource management, and enhancing urban planning. These findings underscore the versatility and efficiency of artificial neural networks in geomorphological and environmental studies, providing a robust framework for future research and practical applications.

Keywords:

Artificial Neural Networks, Frequent neural networks, reverse diffusion algorithms, Automated Learning, Deep Learning, Chatgpt4, Gemini pro 1.5

Introduction:

Artificial neural networks (ANNs), recognized as mathematical algorithms, constitute effective solutions for addressing diverse problems across scientific research.

It can also be defined as a computer model that aims to simulate the human mind.

This implies that the human mind comprises a network of neurons. Similarly, neural networks (NNs) are composed of interconnected artificial neurons. Consequently, they can mimic the function of human neurons, enabling them to perform highly complex tasks and operations that are challenging for conventional computer programs to execute.

Neural networks can also be defined more simply as interconnected layers of small units called nodes, which perform mathematical operations to detect patterns in data.

Algorithms have been designed to mimic the functioning of human neurons. The applications of artificial neural networks (ANNs) in analyzing aerial images and satellite imagery have a significant impact on many critical fields. This technology is powerful and effective in analyzing and interpreting satellite images, much like the human brain, as it learns patterns and utilizes them to identify and classify various shapes and features within the images. (Ajwa, W. M., 2024, p. 211)

The most significant applications of artificial neural networks (ANNs) in analyzing aerial and satellite images include object recognition, landmark identification, and geographic shape detection. ANNs can learn representations of various objects, shapes, and geographic landmarks. Furthermore, they are employed in the creation and analysis of Digital Elevation Models (DEMs) and in examining aerial and satellite images to assess environmental changes and various geographic regions.

Artificial neural networks are also used Artificial Neural Networks In classifying aerial images and satellite visuals based on various characteristics such as wave classification supervised, non-wave classification unsupervised classification for different geomorphological and geographic units (natural, human).

Artificial neural networks are also used in automatic landmark detection, as they can be used in automatic recognition of geographical landmarks such as mountains, rivers, buildings, etc. Artificial neural networks help in digital elevation modeling using satellite images, by creating 3D models.

Environmental change detection, such as monitoring ice recession and urban expansion, represents one of the most significant applications of artificial neural networks achieved by comparing historical images with contemporary ones.

Neural networks can also be applied in positioning systems and geographical data mining, where they analyze large geographic datasets to uncover patterns and relationships, enhancing environmental understanding.

Neural networks can improve aerial images and space visuals based on different characteristics. There are many improvement processes taking place on Satellite images and visuals, such as spatial enhancement operations, radiological enhancement, spectral and topographical enhancement operations, and other optimization operations that artificial neural networks help perform on satellite Imagery and visuals.

From this presentation, the significance of artificial neural networks and their applications in the field of geography, particularly within geographic information systems and remote sensing, is evident. The mentioned applications are just a subset of the many roles that artificial neural networks can fulfill. Further exploration of additional applications will be elucidated throughout the research.

The objectives of the study are highlighted in the following points:

The importance of this research is emphasized through the following objectives:

1-Emphasizing the role of artificial neural networks in analyzing aerial and satellite imagery. This research demonstrates how neural networks can be utilized to enhance the accuracy of aerial photos and satellite imagery analysis, thereby extracting more precise and detailed environmental information.

2-Presenting a practical case study of designing a neural network for predicting landform evolution, this research provides an applied demonstration of the methodology used to design and train a neural network for forecasting landform changes in the southern Sinai Peninsula region. This case study serves as a template for developing analogous applications in different geographical areas.

3- Contributing to the development Use Neural networks in geographical studies, as the research encourages further studies to evaluate the performance of neural networks in other geographical applications.

4- Improving our understanding of the environment and planning for the future better, where can Use the results of this research to improve our understanding of the environment and the changes that occur in it, which helps us plan better for the future and take informed decisions on natural resource management and environmental protection.

5- In general, this research and study highlights the great potential of artificial neural networks in analyzing aerial photos and satellite imagery, supporting decision-making in the field of geographical studies, achieving sustainable development goals, and serving society.

Research Methods, Study Methods, Tools, and Software Used:

In this study, various data, sources, and research methods were employed as follows:

Research Approach: The study adopted a descriptive approach to elucidate the use of artificial neural networks in analyzing aerial photographs and satellite imagery within geographical studies. Additionally, an experimental approach was employed to design and train a neural network for predicting geomorphological changes in the southern Sinai Peninsula.

Methods Employed: The research methods included comprehensive data collection and analysis. Geographical and geological data were gathered from diverse sources, including satellite images and geological maps. These data were analyzed using remote sensing techniques and geographic information systems.

A convolutional artificial neural network (CNN) was designed and trained using the collected data. Various techniques were applied to enhance network performance, such as parameter tuning and normalization methods.

The performance of the trained network was evaluated using test data, employing multiple metrics including accuracy, sensitivity, and precision.

Software and Tools Utilized:

1. Python programming language was utilized extensively for designing and training the neural network.
2. TensorFlow, an open-source machine learning library, was employed for developing machine learning models.
3. Keras, another open-source library, was used for constructing deep learning models and training neural networks.
4. Geographic Information Systems (GIS) software ArcGIS was employed for geographical data analysis.
5. Erdas Imagine software, a remote sensing application, was utilized for satellite image analysis and feature extraction.
6. Artificial intelligence applications like Claude.ai, Copilot, and Gemini 1.5 Pro were utilized for advanced file and data analysis.

Utilization of aerial and satellite imagery across diverse scientific research fields:

Aerial photos are characterized by many features and characteristics that make them a technical tool used in many engineering, geographical, environmental and military fields. The most important of these features is accuracy. This allows accurate measurements such as measuring distances, areas, etc. Aerial photos also cover large areas of the Earth's surface, which facilitates the mapping of various geographical features and phenomena.

Aerial photos are also characterized by the ability to produce maps from them, and this takes less time, making them less expensive than relying on field cadastral measurements.

Some types of aerial photos also provide a three-dimensional image "3D" for spatial features, which facilitates the rapid identification of the nature of geographical features, and also provides the possibility fee Topographic maps that represent the topography of the Earth's surface. Aerial photos taken at different time periods also have the advantage of being able to follow temporal changes in geographical features, such as following the movement of sand and dunes. Thus, determining the extent of its danger and threat to buildings, facilities, villages, water resources, agricultural lands, and others.

One of the most important features of aerial photos is also their ability to clarify geographical features and their characteristics that cannot be seen by the human eye, especially when photographing with infrared rays (such as distinguishing between a healthy plant and a plant infected with pests and diseases) in an agricultural area. Aerial photos highlight the mutual spatial relationships between phenomena, as a result of their specific drawing scale. Aerial photographs are not linked to the political reality between countries of the world, as it is possible to obtain highly tilted photographs, for example, of a border area between two countries and it counts Aerial photos are one of the most important techniques in highlighting features located below the surface of the Earth at simple depths, such as under ground water. Aerial photos can also highlight spatial features in remote areas that are in accessible to humans to get it easily located on the surface of the Earth, such as desert areas, including the Sinai Peninsula, the case study area in the research. (Mohamed, A. M. M., & Ghazai, A. E. 2021).

One of the most important applications of aerial photos is the production and updating of maps, because they are accurate, comprehensive, and cheap. As Prepare Taking advantage of aerial photos to interpret geographical features and deduction Accurate and up-to-date information about it is one of the most important applications of aerial photos in a large number of applied and development works and projects, such as agriculture, soil, environment, geology, Figure (4, 5, 6, 7), urban planning, civil engineering, as well as transportation, population, traffic, military applications, and others. In the case of analyzing aerial photos and satellite() imagery, the neural network may consist of several successive layers Figure (1) as follows:

1- First class (Input layers)

This layer accepts aerial or satellite imagery as input. The image is appropriately formatted within this layer—for instance, it is characterized by its dimensions and color channels like RGB. Each element within this layer encapsulates pixel data, usually delineated by image dimensions and color channels. For color images, each pixel comprises three values—red, green, and blue—to depict color accurately. This formatting ensures the image is prepared for subsequent processing and analysis in a scientifically precise manner.

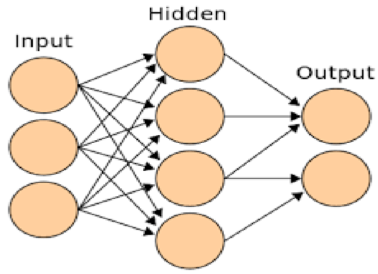

Figure (1): The neural network Used to analyze satellite imagery
Source: Alaa Tahaimah, Faculty of Computer Science and Information Technology, Qadisiyah University,

2-Hidden layers:

It comes after the first layer and takes the features present in the Aerial Photos or Satellite imagery and works to extract more patterns, characteristics, and important information. The neural network may contain several hidden layers, and each layer extracts more information. Each layer transforms the input signal and applies weight, bias, and activation function to extract more useful information.

3-The resulting layer (Output layer)

It receives the processed data from the hidden layers and works to give the desired result. In the case of analyzing aerial photos, the class the result may be Categories the image can be divided into different categories such as forests, cities, water, mountains, etc. Or it may be a set of numerical values that represent specific characteristics of the image, such as plant density, land level, etc. And an artificial neural network designed for an aerial or visual satellite image may be simple, but in general the artificial neural networks used in image analysis are complex as they may contain many hidden layers and advanced techniques. The greater the number of hidden layers, the greater the complexity of the neural network, and each layer attempts to extract more patterns and characteristics in the aerial photos. It is important to mention that the design of a neural network depends on the specific type of problem and data used. Figure (2)

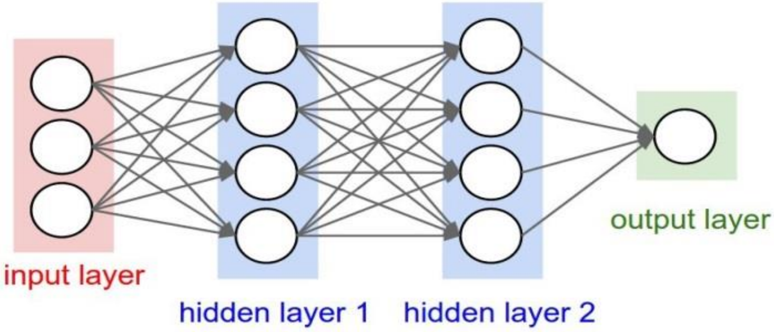

Figure (2): A more complex neural network for analyzing satellite imagery and aerial photos

Source: Synthetic neural networks, link, https||:images.app.goo.gl| Bt3jAdiBzmrs D8s57

Basics of artificial neural networks:

The basics of an artificial neural network consist of several elements as follows:

- **Neurons:** They are the basic units of a neural network, and each neuron receives inputs from other cells and calculates a single output signal and sends it to other cells.
- **Connection:** Neurons are connected to each other by links, and each link has a weight represents strength and importance Connection.
- **Activation function:** It converts incoming signals into the cell and converts them into a single output signal, Sigmoid, and ReLU.
- **Forward Propagation:** Data is propagated from an input layer to a hidden layer to an output layer to obtain the network results.
- **Back Propagation:** It calculates the network error and adjusts the connection weights to reduce the error through the learning process.
- **Learning:** Adjusting link weights to improve network performance through exposure to training examples. And these components the basic artificial neural networks enable neural networks to learn complex models to solve problems such as classification and prediction. This is extremely important in geographical studies in general and natural geography in particular.

If a neural network is drawn for image classification, it can consist of an input layer, two hidden layers containing several neurons, and an output layer with a number of cells representing the required classification categories. In the case of drawing a simple neural network for image classification, it can contain three categories (Class 1, Class 2, and Class 3). The network consists of an input layer that receives the image to be classified as input to the network, and two hidden layers, each of which contains a number of neurons that process and extract Features from the image, also contained in the output layer which contains number from The cells represent classification categories, and they classify the image into the appropriate category. The learning process takes place by adjusting weightsweights Network connections based on labeled training data. Below is a proposed illustration of building a neural network used in analyzing and classifying Aerial images and satellite visuals.Figure (3)

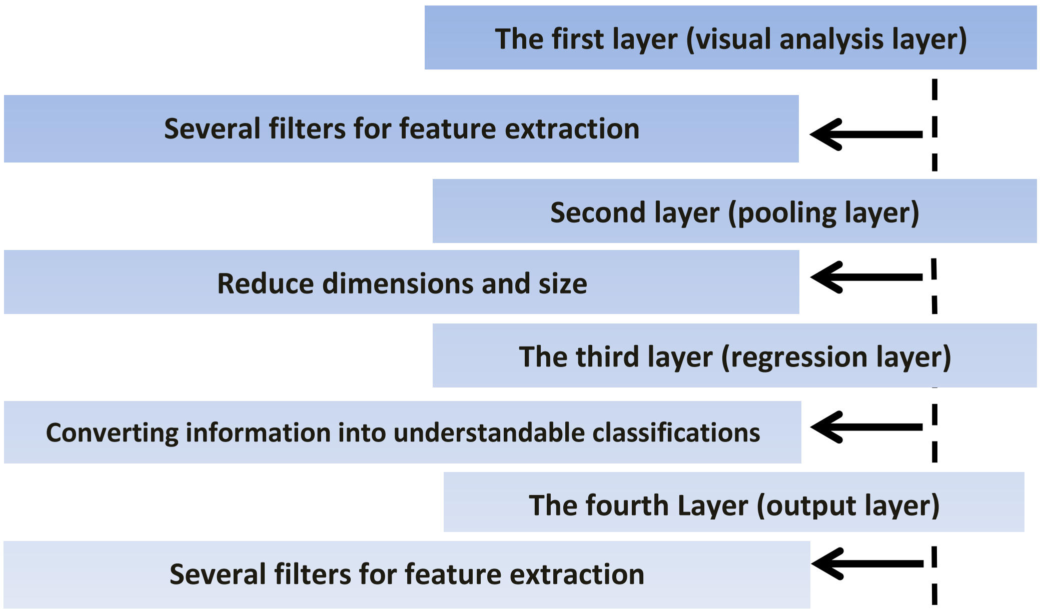

Figure (3): The neural network used to classify satellite imagery images.

Source: Researcher

Principles of neural networks in the geographic field:

How to apply the principles of artificial neural networks in the geographical field includes the following:

- Entering geographical data and feeding the neural network with geographical data such as remote sensing data and digital elevation models (DEM), maps, aerial photos, etc.
- Data processing is performed by a neural network by extracting the features, and patterns from geographical data through its hidden layers.
- Learning and inference where the network adjusts weights its connections via learning algorithms to be able to infer geographic knowledge from data.
- Spatial modeling is where neural networks are used to model geographic phenomena such as the spread of drought or floods.
- Spatial forecasting, where neural networks allow predicting future geographical events or models such as the expansion of deserts.
- Feature Classification Neural networks can classify geographic features such as soil types and vegetation.
- Decision making is also one of the most important principles Neural networks in geographic studies (natural and human), where the results of artificial neural networks are used to make spatial decisions related to city planning or disaster management.
- Detection of changes: Neural networks can detect changes in geographical features by comparing aerial photos and satellite imagery over time.
- Data fusion: Artificial neural networks can combine geographic data from multiple sources and types (images, maps, and field data) to obtain more accurate results.
- Spatial pattern analysis by identifying and modeling spatial relationships in geographic data, such as the spread of epidemics or population distribution.

- Remote sensing also involves processing and analyzing remote sensing data such as aerial photos using neural network algorithms.
- Artificial neural networks are also used to improve the accuracy of geographic information systems this is to increase the accuracy of spatial data and predictions.
- Detect and recognize complex patterns in huge geographic data using deep learning techniques.
- One of the most important applications of the principles of artificial neural networks is also soil classification, which is done by training the neural network on satellite imagery, such as: Land Sat,ETM or Spot And also geological data, where it can learn patterns to classify and identify soil types. And also from principles the mission that may be it is applied through artificial neural networks to model soil erosion, by using neural networks to model and predict soil erosion rates based on climate factors, soil characteristics, and vegetation cover.
- Climate change analysis is done by training the artificial network on historical climate data, and it can detect patterns and model the effects of climate change.

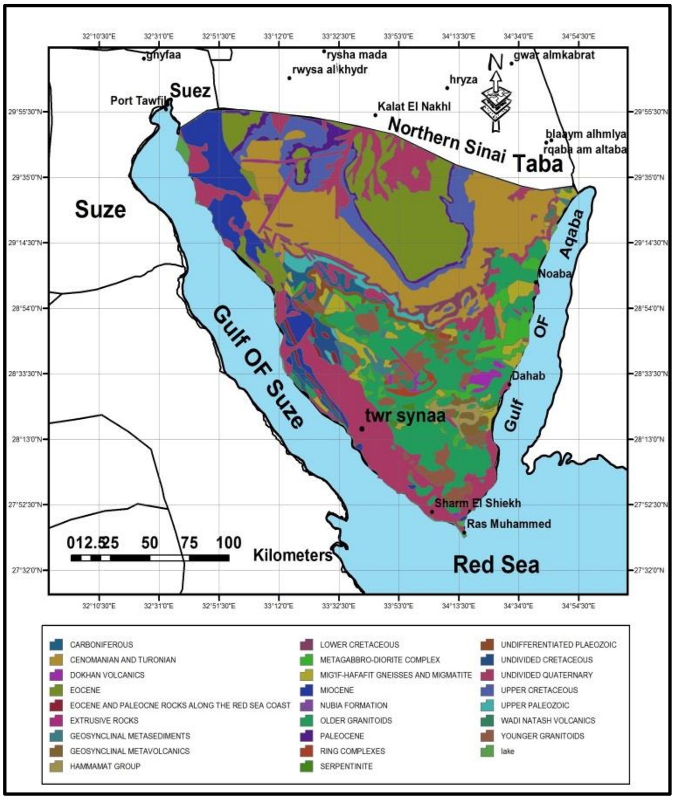

Figure (4): Geology of the Sinai Peninsula

Figure (5) of surface sediments in the central sector from a fan valley Single and note the size of the sediment which indicates the severity of the floods in the region, the filming direction is towards the south west

Figure (6) of granite rocks in the central sector of the Wadi al-Khabb fan, and we notice the formation of caves with granite rocksThe direction of photography is towards the east

Figure (7) of geological formations, Sharm El-Sheikh Road, photography direction towards the North West

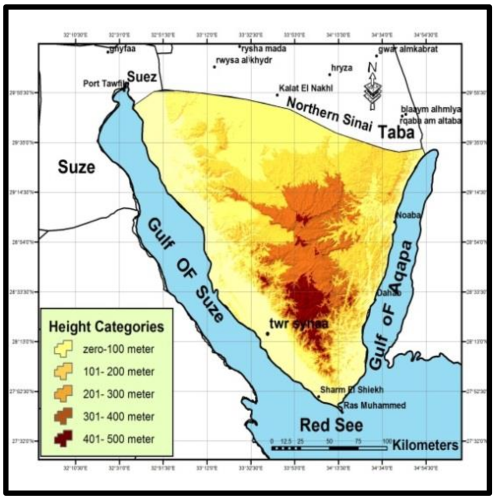

Figure (8) Map of elevation categories in South Sinai governorate

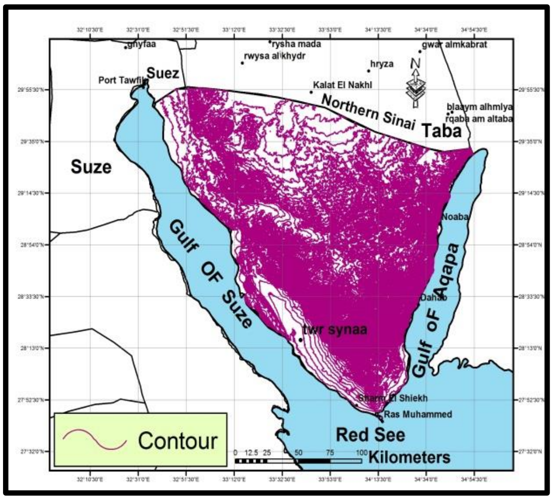

Figure (9) Sinai Peninsula Contour

- Artificial neural networks are used in studying earthquakes to analyze geophysical data in order to determine the locations of potential earthquakes and predict their intensity.
- Important applications include geological mapping using remote sensing data and geophysical measurements, as artificial neural networks help in drawing accurate maps of geological formations. **Figure** (4, 5, 6, 7).

Artificial neural network used in geological map analysis:

Artificial neural networks are utilized in the field of Earth sciences (Geography and Geology) for processing and analyzing geographic and geological data. In the field of Geology, they are employed in interpreting geophysical data, where artificial neural networks are used in analyzing geophysical survey data such as gravity and magnetic data, as well as resistivity data, to assist in determining the geological structure beneath the Earth's surface. (Al-Deen & Van der, 2018, pp. 59-74) Artificial neural networks are also used in the geological field for analyzing remote sensing images; where networks can be trained to classify and interpret satellite images and aerial photographs to identify surface geological features such as rock types, fractures, and folds. Artificial neural networks can also be used in analyzing multiple sets of geological and geochemical data to predict the presence of mineral deposits.

The importance of using artificial neural networks in the geological field also lies in analyzing well log data to interpret geological structures and identify locations of reservoir rocks for oil and natural gas. The importance of artificial neural network applications in the geographical field also lies in the classification of rock types and geological structures. Neural networks can be trained on large databases of remote sensing images and their associated geological data to learn to accurately classify rock types and geological structures such as folds and faults. This aids geographers in creating more precise geological maps.

The research and study also demonstrate the significance of artificial neural networks for geographers in exploring new regions. Artificial neural networks can be used to analyze remote sensing data and geophysical data of the explored areas, and to create models of potential subsurface geological structures. This aids geographers in guiding geological exploration efforts in the region.

The study of artificial neural network applications in the geographical field demonstrates their importance in monitoring geological changes. This is achieved through using artificial neural networks to compare remote sensing images and geological map data across different time periods to detect changes in geological features, such as movements of folds and faults, rock erosion, and so forth. (Khan, S., Ahmed, R., Mustafa, F., 2018, p. 927)

Artificial neural networks can also be trained on geological, climatic, and hydrological map data to model geomorphological processes such as erosion and deposition (Figure 5), which helps geographers better understand the evolution of the Earth's surface. Neural networks can also be used in predicting geological hazards, by analyzing geological and geospatial data to forecast areas at risk from geological and geomorphological hazards such as landslides, floods, and torrents (Figure 1); this aids in urban planning and disaster preparedness.

Through research and study, it becomes apparent that designing artificial neural networks for analyzing geological maps requires multidisciplinary skills that integrate geology; digital geography, data science, and artificial intelligence.Network architectures and appropriate algorithms are selected based on the nature of the problem and the available data.

When drawing the geological map of the Sinai Peninsula, several critical elements are considered to ensure an accurate and functional depiction of the region's geological characteristics:

Firstly, various rock types prevalent in the area, including igneous, sedimentary, and metamorphic rocks, are identified. Specific rocks such as marble, granite, and basalt are marked based on their mineral compositions and observable characteristics.

Secondly, detailed representations of geomorphological and topographical features, such as mountains, valleys, and plains, are included. Dry valleys like Wadi Dahab, Wadi Zaghra, El Khashab, and El Nasb are significant geological and hydrological features in arid regions.

Thirdly, areas covered by different types of sediments, such as sand deposits along coastal plains, are represented using specific colors and symbols. This aids in understanding sediment dynamics and potential land use or geological resources fourthly, the map highlights rugged mountainous terrains forming a significant part of the Sinai Peninsula. Mountains such as Mount Saint Catherine, Mount El Tor, and Mount Um Shomer are prominently featured with detailed topographical contours to illustrate their elevation and terrain ruggedness.

Fifthly, fault lines and other structural geological features are meticulously detailed to understand geological stability and tectonic activities. This includes areas of significant tectonic activity influencing seismic risks and rock formations.

Sixthly, coastal features, particularly the coastal plains along the eastern coast of Sinai, are depicted, essential for studies related to coastal erosion, sea-level changes, and coastal ecosystems.

Seventhly, modern geological mapping integrates data from various sources using advanced technologies such as Geographic Information Systems and remote sensing data. Machine learning techniques, like training convolutional neural networks, are applied to analyze large datasets and create detailed maps reflecting complex geological structures more comprehensively.

By considering all these elements, a geological map of the Sinai Peninsula can serve as a crucial tool for geologists, environmental planners, and researchers, providing insights into the region's geological history, resource management and environmental conservation.

A proposed applied model for designing a neural network to predict geomorphological changes from the geological map of the southern Sinai Peninsula:

Completing this work requires several steps:

1- **Data collection:** represented by geological maps of the South Sinai region over long periods of time, and also collecting satellite images or aerial photographs of the region.via Different time periods, climate data (temperatures, precipitation, winds) for the region, and hydrological data (water course networks, flood areas).

2- **Data processing:** such as converting maps and aerial images into digital data (pixel matrix), and converting climatic and hydrological data into temporally organized digital values.

3- **Determine the inputs and outputs of the neural network:** The inputs, which are represented by geological map data, include data Sensor Telematics, climate and hydrology data.

The outputs are the expected geomorphological changes, such as rates Drift Erosion and sedimentation.

4- **Choosing a neural network structure:** to deal with data chronologically (RNN) or recurrent neural networks (LSTM) Long-term retention networks, the number of hidden layers and the number of units in each layer depending on the complexity of the data.

5- **Neural network training:** where the data is divided into training sets and test, and choose Suitable training algorithm e.g Training Regression or repetitive training. Then train the network using and adjusts the structure and training algorithms to get the best performance.

6- **Network validation:** Testing the trained network using Data the test and evaluation of predictions of geomorphological changes.

7-**Application:** The trained network is reused to predict geomorphological changes the future in South Sinai Peninsula region and retrain the network periodically using new data to improve its accuracy.

The researcher proposes an initial code for designing the neural network to be designed as follows:

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
import numpy as np
#Loading data (assume we already have the data innumpy arrays)
X_train, y_train = load_data('train_data.npz')
X_test, y_test = load_data('test_data.npz')
#Determine the structure of the neural network
model = keras.Sequential([
layers.Input(shape=X_train.shape[1:]),
layers.LSTM(64, return_sequences=True),
layers.LSTM(32),
layers.Dense(y_train.shape[1], activation='linear')
])
#Network processing
model.compile (optimizer='adam', loss='mse', metrics=['mae'])
#Network training
history = model.fit(X_train, y_train, epochs=50, batch_size=32,
validation_data=(X_test, y_test))
#evaluating the trained network on test data
test_loss, test_mae = model.evaluate (X_test, y_test)
Print (f'Test Loss: {test_loss}, Test MAE: {test_mae}')
#Save the trained network
model.save('geomorphological_changes_model.h5')
```

Data can also be added automatically through the following code: Data can be handled more efficiently by using a library pandas in python we can add steps to automatically save data in the code as follows.

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
```

```
import numpy as np
import pandas as pd
#Loading data from filesCSV
geological_maps = pd.read_csv('geological_maps.csv')
satellite_images = pd.read_csv('satellite_images.csv')
climate_data = pd.read_csv('climate_data.csv')
hydro_data = pd.read_csv('hydro_data.csv')
#Processing and converting data intonumpy arrays
X_train, y_train = process_data(geological_maps,
satellite_images, climate_data, hydro_data, train=True)
X_test, y_test = process_data(geological_maps,
satellite_images, climate_data, hydro_data, train=False)
#Save processed data in filesnumpy
np.savez('train_data.npz', X_train=X_train, y_train=y_train)
np.savez('test_data.npz', X_test=X_test, y_test=y_test)
#Determine the structure of the neural network
model = keras.Sequential([
layers.Input(shape=X_train.shape[1:]),
layers.LSTM(64, return_sequences=True),
layers.LSTM(32),
layers.Dense(y_train.shape[1], activation='linear')
])
#Network processing
model.compile(optimizer='adam', loss='mse', metrics=['mae'])
#Network training
history = model.fit(X_train, y_train, epochs=50, batch_size=32,
validation_data=(X_test, y_test))
#Evaluating the trained network on test data
test_loss, test_mae = model.evaluate(X_test, y_test)
print(f'Test Loss: {test_loss}, Test MAE: {test_mae}')
#Save the trained network
model.save('geomorphological_changes_model.h5')
```

Source: Researcher, using a program and application Claude.ai, Chat Gpt4 and apply the 80|20 rule and evaluate the accuracy of the results

What the researcher did can be summarized in the following steps:

1- Download the necessary data from files CSV and that using library Pandas in Python This data include geological maps, satellite imagery, climate data, and hydrological data for the South Sinai region.

2- After loading the initial data, the program starts creating a function named Process data to process this data, convert it into matrices NumPy Suitable for use in neural network training. We note that the function is not defined in the presented and proposed code, because it is complex and linked to private data.

3- Divide the processed data into two sets (training set X Train, Y Train), and a group a test (X text, Y text).

4- Then the processed data were saved in files NumPy using Function. Savez from a library NumPy this facilitates the process of loading the processed data later without having to process it again.

5- Define the structure of a neural network using Keras from Tensorflow the structure consists of two layers LSTM And density layer One external. The user can modify this structure according to the needs of the problem.

6- Finally, the network is prepared for training using Training algorithms Adam, and the least squares loss function (MSE).

7- The researcher trained the neural network on training data for 50 training sessions (epoch), with the use of data the test to check network performance.

8- The trained network was evaluated on data the test, and values Loss the test and average absolute error.

9- In the end, I saved the trained neural network in a file to use the subsequent prediction of geomorphological changes in the South Sinai region.

A library can also be used PyTorch in Python to build a neural network, the proposed code for this is as follows:

```
import torch
import torch.nn as nn
#Define the structure of a neural network
class GeomorphologicalChangesNet(nn.Module):
def __init__(self, input_size, hidden_size, output_size,
num_layers):
super(GeomorphologicalChangesNet, self).__init__()
self. hidden_size = hidden_size
self.num_layers = num_layers
self.lstm = nn.LSTM(input_size, hidden_size, num_layers,
batch_first=True)
self.fc = nn.Linear(hidden_size, output_size)
def forward(self, x):
h0 = torch.zeros(self.num_layers, x.size(0), self.hidden_size)
c0 = torch.zeros(self.num_layers, x.size(0), self.hidden_size)
out, _ = self.lstm(x, (h0, c0))
out = self.fc(out[:, -1, :])
return out
#Define network parameters
input_size = 64 #Number of entries (must be adjusted depending
on the data)
hidden_size = 128 #Number of units in hidden layers
output_size = 3 #Number of outputs (for example: rates of
erosion, erosion, sedimentation)
num_layers = 2 #Number of layersLSTM
#Create a neural network model
model = GeomorphologicalChangesNet(input_size, hidden_size,
output_size, num_layers)
#Determine the loss function and optimization parameter
criterion = nn.MSELoss()
optimizer = torch.optim.Adam(model.parameters(), lr=0.001)
```

This code consists of the following:

1-It was completed identification Structure of artificial neural network Basim Geomorphological Changes Net It consists of two layers LSTM, and varied with an outer layer of density.

2-The number of inputs, the number of units in the hidden layers, the number of outputs, and the number of layers are determined LSTM As network parameters.

3-A neural network model is created using Specific parameters.

4-The loss function is determined usingnn.MSE Loss()And define the optimization parameter using.Torch.optim.Adam

This is a basic design of a neural network, but it can be modified depending on the actual project requirements and the nature of the data. The researcher will also have to modify the inputs and outputs, according to the type of data, and also modify the number of layers and hidden units as needed. After designing the network, the data is loaded, divided into training and test sets, and then the network is trained using Training algorithm and evaluating it on data the test.

The conclusion of this part of the research, which sheds light on the importance Use Artificial neural networks in predicting geomorphological changes from geological maps, is to determine the main type of artificial neural network used in this project is a recurrent neural network. Recurrent Neural Network-RNN, with layers of long-term memory (Long Short-Term Memory-LSTM), and recurrent neural networks such as LSTM Figure (10) Suitable for handling time-series or serially correlated data, such as the geological and hydrological data series used in this project.

Have layers "LSTM" An internal memory that enables it to remember previous information in the sequence when processing the current data. In the design of the artificial neural network presented in this research, it consists of three successive layers (Python, Code)

```
model.add(LSTM(128, input_shape=(sequence_length, num_inputs),
return_sequences=True))
model.add(Dropout(0.2))
model.add(LSTM(64, return_sequences=True))
model.add(Dropout(0.2))
model.add(LSTM(32))
model.add(Dropout(0.2))
```

Where you receive the first layer LSTM Sequential inputs, passes them to the next layer, the second layer processes these sequential outputs, passes them to the third layer and so on. This sequence of layers LSTM Figure (10) Knowing that long-term memory networks operate through some gates that control the flow of information within the network, depending on whether the information is considered important or not, and it can For this Gates can either allow entry or prevent them. It also enables call up Or forgetting information from past time steps, which something Adult Importance for time series is forecasting. (TIME-SERIES PREDICTION). (Ajwa, 2024, pp. 194-195)

And it can for the network Discover complex relationships and long-term predictions in sequential data. And after layers LSTM, a density layer is added External to predict geomorphological variables. (Python, Code, copy).

```
model.add(Dense(num_outputs, activation='linear'))
```

Therefore, the main type of neural network used is a network Nervous frequent (RNN) Figure (10, 11) with layers LSTM to deal with time series data related to geomorphological changes.

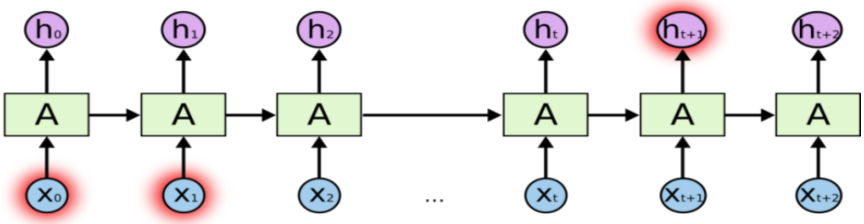

Figure (10): Neural network with long short-term memory.LSTM"

Source: Tony Yiu, Neural Networks, 2019 link, understanding Neural Networks, https||toWardsdatascience.com

Where neural networks are Self Long-term memory LSTM shapes a form of recurrent neural network RNN It can learn and memorize long-term dependencies and was built specifically to handle sequential input (Walid Muhammad Ajwa, 2024, pp. 194, 195).Figure (11)

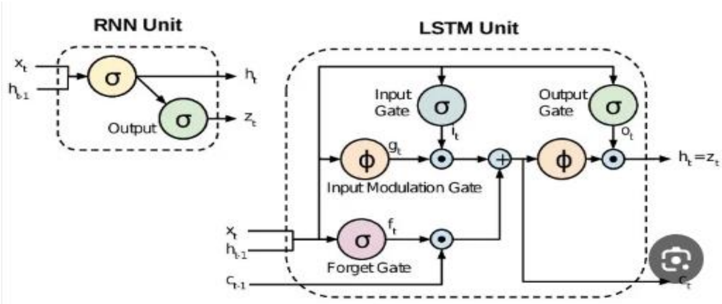

Figure (11): Long memory neural network units."LSTM" term, recurrent "RNN"

Source: Data Science Duniya, Learn Data Science, Machine Learning and Artificial Intelligence, Ashutosh Tripathi, 2021. Link, https:||images.app.goo.gl|KQEPuVQD2rLrh wk2A.

Neural network Synthetic Used in analyzing the digital elevation model for the Sinai Peninsula:

Artificial neural networks are computer models inspired by the human brain, and rely on networking many computational units connected to each other.

Artificial neural networks are used in many applications such as deep learning.Classification and prediction and using the appropriate programming language, and we believe that the best and easiest programming language in this matter is the language python, where a neural network can be drawn Artificial and her training using A collection of data to achieve improved performance in the required task.

To design a geographical artificial neural network (analyzing natural and human features), data must be provided so that the network can provide optimal solutions. A neural network can be drawn and designed Artificial to classify digital height classes from the digital model (DEM).

To achieve this, some preliminary information must be provided, such as the size of the available data and the number of categories to be classified in the digital height. It is necessary to ensure that the data is prepared appropriately, by dividing it into the Training Set And the Test Set After that, we can use the appropriate programming language, such as: Python And using libraries such as TensorFlow or Keras To build the neural network using multiple layers such as input layers, upsampling layers and classification layers.

The training data set is used to train the neural network Finish From the training process, and it is used next, a data set the test to evaluate the network's performance and accuracy in classifying digital elevation categories.

May be Use entered data Inputs On the information to achieve an accurate classification of digital height categories in the South Sinai region using artificial neural networks?

Artificial neural network for its design and accuracy, it requires digital elevation data (DEM) which are measured in appropriate units such as metres). Data can be obtained "DEM", cleaning and grouping them into appropriate groups and categories based on the information of the research and study area (southern Sinai Peninsula).The categories can be such as the highest mountain peaks, valleys, plains, towering mountains, rugged terrain, etc.

Then the neural network is built and trained "ANN" using this data is aggregated and category specific. The network is directed to learn and recognize certain patterns in the data that represent the different categories of heights. Network parameters are adjusted and performance is improved through several training sessions.

After Finish from training the network, it can Use it to classify new data related to elevations in South Sinai. This can help in understanding the topography and mountainous terrain and identifying places with specific elevations.

The more data, information, and details that are input into the network, the higher its accuracy and capability to analyze and classify, thereby yielding more precise results. Digital elevation data obtained from satellites offer detailed insights into the elevations of a region. This data can be utilized to categorize various height levels accurately.

The region's rugged terrain and mountainous terrain provide exciting opportunities for study and analysis BaUse Appropriate data. Where can aUse deep learning techniques "DL" and artificial neural networks for learning AndaYou will be saved Patterns and important information from this data.

Analysis and classification of data from the digital elevation model will be important for understanding the nature of the area and benefitfrom data In many fields such as transportation planning, energy and environment And sustainability And others.

Digital elevation data can also be used to perform predictive and predictive analyses, such as determining terrain hazard and estimating geological slope. Neural networks can also be used to process these analyses, and strengthen s! You turned us around on the to understand and forecasting phenomena and changes in the region "south of the Sinai Peninsula".

Steps to design and implement an artificial neural network for digital elevation model analysis:

A neural network can be designed to precisely classify and analyze digital elevation categories in South Sinai using satellite-derived digital elevation data.

This approach enables the accurate assessment of terrain variations across different elevation bands.

- We start by preparing and collecting digital height data and converting it into a form suitable for neural training. We collect accurate and comprehensive data for the South Sinai region, and then we design the artificial neural network using deep learning techniques "DEM", such as multi-layer neural networks, then we try to determine the appropriate structure and the appropriate number of layers and units in the network, in order to achieve the best classification performance.
- After that, Complete to divide Elevation data to a Training set and a group a test Test Set, and verification set for evaluation. The training set is used to train the network and the test set to evaluate its performance and ability to accurately classify. Then use the verification suite to adjust and improve network parameters if necessary.
- After training the network, we evaluate its performance using metrics Normative and accuracy criteria such as correctness rate, false positive rate, false negative rate, etc. Here, the network will accurately classify and understand the structure of elevations in the South Sinai Peninsula Governorate.
- After training the network, we evaluate its performance using metrics the standard and accuracy standards mentioned above.

After completing the design and training of the neural network, we can Use it to classify new data related to elevations in the South Sinai region. The network will contribute to a better understanding of the region and provide useful insights into the relief, geological formations, and mountainous terrain.

The stages involved in implementing a neural network for digital elevation model analysis can be summarized as follows:

1- Preparing digital elevation data and converting it into a format suitable for neural training. Subsequently, we transform this data into a digital matrix and format it in a manner that aligns with the input requirements of the neural network.

2-Multilayer neural network architecture design. The number of layers and the number of units in each layer are determined, and the appropriate activation functions for each unit in the network are chosen. The network design depends on the size and complexity of the data set.

3-Divide the height data into a training set, a test set, and a validation set. Then use the training set to train the network and the set the test to evaluate its performance and ability to accurately classify. Then use the verification suite to adjust and improve network parameters if necessary.

4-Train the network using an appropriate machine learning algorithm such as...Spread the opposite Backpropagation. Then you will adjust the weight of the connections between Units In the network and that to improve Performance. This process will be repeated until we obtain satisfactory and accurate data classification results.

5-Finally, we will evaluate the network performance using metrics Standards such as the correctness rate, the false positive rate, the false negative rate, and the accuracy rate. We will confirm that the network accurately classifies and understands the uplift structure in the southern Sinai Peninsula.

6-A programming code will be prepared in the language Python To implement this neural network; the code will include the appropriate algorithms and functions used in the network.

The digital elevation model can be applied (DEM) on the southern Sinai Peninsula Figure (8, 9) to determine the different elevation levels in the area. This helps in understanding Sinai's topography better and identifying mountainous areas, plains, valleys, and other geographical features.

The important steps that can be followed to apply the digital elevation model to the Sinai Peninsula can be identified.

- **Data collection:** applying a digital elevation model requires collecting geological data from a variety of sources. Complete Use Technologies such as Remote Sensing and lasers and drones to collect 3D geological data.
- **Data processing:** After data is collected, it is processed to remove noise, correct errors, and improve accuracy. Maybe Use Programs like Geographic Information System and Remote Sensing Softwarefor this purpose.
- **Create the form:** After processing the data, a digital elevation model is created that represents the different elevations in the area. And it is done Use Data science and spatial analysis techniques to accurately create the model and professionalism.
- **Data analysis:** Once the model is created; the data can be analyzed to extract useful information. Mountains, plains, valleys and other areas of different heights can be identified in Sinai.
- **Data visualization:** Data is depicted in the form of a map showing the different elevations in Sinai. Where possible Use Different colors or elevation curves to achieve this goal.
- **By applying the digital elevation model:** we can get a map showing the topography of Sinai and its heights this is useful in many fields such as urban planning, agriculture, and exploration for natural resources.

Description of an ideal artificial neural network for a digital elevation model:

An artificial neural network consists of multiple layers, called hidden layers, in addition to the input layer, and the output layer. Each layer in the network contains a group of neural units, also known as nodes. (Neurons), which processes and transfers information between layers. And it contains Telecommunications between nodes in the network based on weight, reflects strength Correlation Between the nodes. And it is applied Activation function on the input signal for each Knot, which helps convert it into an output signal. Then the learning process in the network takes place by adjusting the weight and determining the connections between the nodes.using learning algorithms such as Spread the opposite Backpropagation Refer to Figure (12).It is a subject learning algorithm, as it is considered a method for calculating the gradient. It is used to train neural networks for the loss function that takes into account the network weights, which allows deriving by optimizing these weights to reduce loss.

Digital elevation models are considered (DEM) is one of the complex models, and the digital elevation model for the southern Sinai Peninsula is one of the very complex models due to the topography of the region and its complex mountainous nature, as it is a highly rugged and rugged arctic fiery mountain triangle. Deep learning systems are capable of learning very complex patterns, and they achieve this by Adjust their weights. (Haykin, S., & Moher, M. 2021)

Network aims Back propagation that it represents the weights of a deep neural network, it also represents power Telecommunications between network units backpropagation the goal of the neural network must first be determined. And when the neural network is created, the work is done Assumptions about how to connect the units in one layer with its associated layers. And during transition Data via neural network, weights are calculated and placed Assumptions. When the data reaches the final layer of the network. When the data reaches the final layer from the network, where a prediction is made about how Engagement Features by categories. (AI Index Report, 2021, Human-Centered AI Institute, Stanford University).

The network is divided Spread The reverse is divided into two types: network Spread Inverse recursive, which is one of the types of networks that aims to produce a mapping of a fixed input to a fixed output, and these types of networks are capable of solving fixed classification problems such as optical character recognition (optical character recognition.(OCR), and the second type is known as a network Spread Periodic recurrence, which is another type of network used in learning With dots Static, where activations in the iterative backpropagation are fed forward until they reach a fixed peak, after which the error is calculated and propagated backward. The applications of this network are to identify and classify geographical features. And get to know the levels ElevationIn order to build a digital Elevation model "DEM" Like a model to raise South Sinai Peninsula.

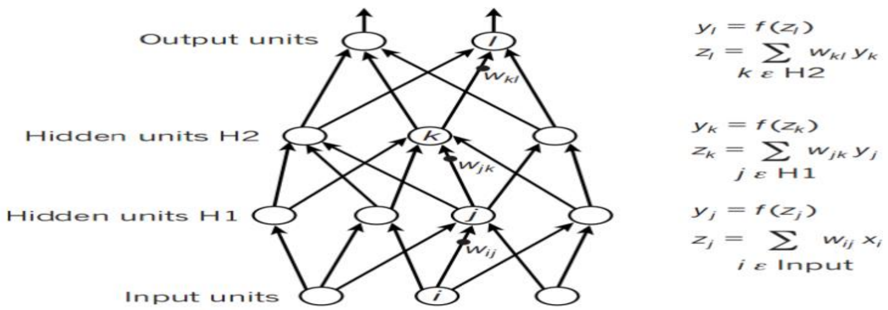

Figure (12) network Spread Reverse (front and back)

Source: link, https:images.app.goo.g1|7GvIymyuFbagwLto

Algorithms Spread Inverse (back propagation):

It is an algorithm Backpropagation A pivotal algorithm in training multi-layer neural networks. Indeed, it is the chain rule for complex functions, but its importance in actual operations is much greater from the base Series. To answer the main question: "How do you explain an algorithm?" Spread Intuitively?" It is necessary to intuitively understand the training of multi-layer neural networks. The inverse propagation method is actually relatively simple, but since it requires a partial derivative, and my mathematics is not very good, it has always been difficult to understand. Figure (13).

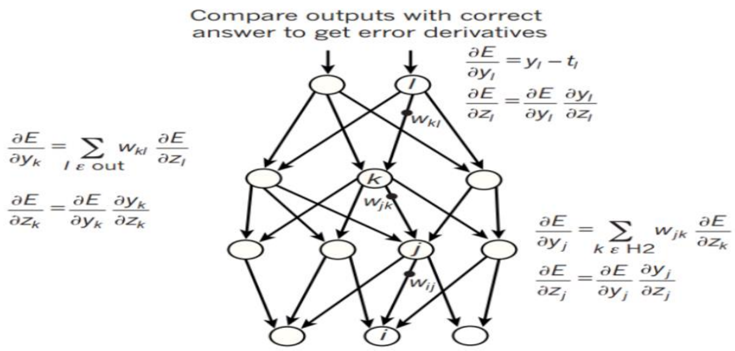

Figure (13) Synthetic neural network used to analyze regression maps

Source: link, https:images.app.goo.g1|7GvIymyuFbagwLto

Artificial neural network used in analyzing regression maps:

The regression algorithm can be applied (**Regression**) on a map of the southern Sinai Peninsula Figure (15) this is to determine the relationship between a response variable and different situational variables.

Regression aims to anticipation the expected value of the variable Response When positional variables are changed.

Steps to apply regression on a map of the southern Sinai Peninsula:

Data Collection Application of regression requires data collection for the response variable and positional variables from the region in question (south of the Sinai Peninsula). These data are collected through field surveys or data available from various sources.

Data Analysis: After collecting the data, it is analyzed to determine the relationship between the variable Response And positional variables, where possible Use Multiple statistics and data analysis methods such as linear regression analysis and non-linear regression analysis.

The map is created based on data analysis. A map can be created that shows the relationship between the positional variables and the variable Response where Use charting techniques such as can chart and 3D charts for visualization Relationship.

Creating a map based on data analysis, where a map can be created that shows the relationship between positional variables, and the response variable. It is possible Use Charting techniques such as graphs and 3D charts to visualize the relationship. Then analyze the map after creating the map, where it can be analyzed to understand the relationship between the positional variables, and the response variable better. Can be specified Direction and strength, and patterns in the relationship using the map.

Suppose we have a map of a city containing information about the population (a variable Response), the number of commercial places and the total area of the city (situational variables). By applying regression to a map, we can determine how the number of commercial places and the total area of a city affect the population. Where we can Use Map to determine the general relationship and forecast the expected population size when the number of commercial places or the total area is changed.

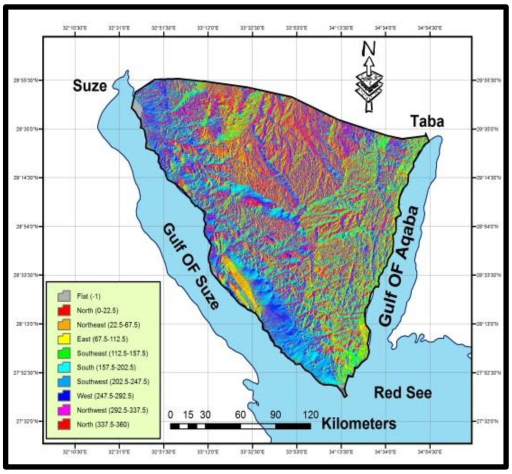

Figure (14) Aspect Map of the South Sinai

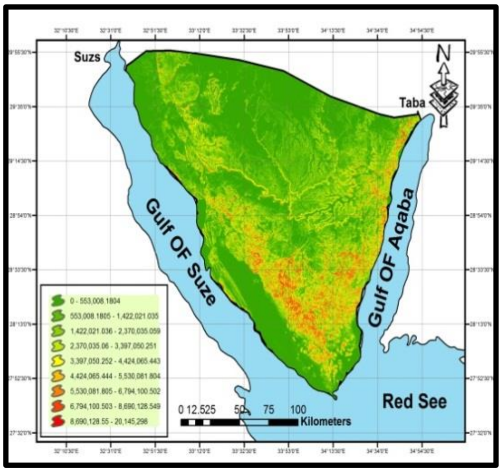

Figure (15) Slope Map of South Sinai

To apply direction slope of layers (Aspect) in artificial neural networks ANN, various algorithms such as optimization networks can be used using deep learning And various types of neural networks, such as multi - layer neural networks.(Multilayer Perceptron) and analogue neural networks (Convolutional Neural Networks), and deep neural networks.

Optimization network using Deep learning:

This network is based on the application of deep learning algorithms Deep Learning to improve model performance and achieve the best accuracy in routing data. Deep learning algorithms such as deep networks can be used to achieve superior performance in determining the direction of inclination of rock layers, as it is evident from the analysis of the map of the direction of inclination in South Sinai Governorate that the slopes of the region vary, and the inclination of the rock layers in the region varies, as we notice from the analysis of Aspect On the western side of the area, a mile Regression The inclination of the layers from east to west, with valleys descending from mountainous ridges such as Wadi Al-Tur, Firan and Abu Dis, towards the Qaa Plain and the Gulf of Suez in the west.The layers also slope and tilt From the east towards the west, where valleys descend, such as Wadi Dahab, Wadi Kid, valley Monument, Wadi Watir, and a map showing the direction of the slope Aspect Which relied on deep learning algorithms Deep Learning And deep neural networks indicate that the general direction of the South Sinai region is from the south towards the north. It also becomes clear how complex the South Sinai region is geologically, geographically, and geomorphologically. This hinders development in the region.

Multi-layer neural network:

This network consists of several interconnected layers, where signals are routed from the first layer to the last layer through the intermediate layers. And it can Use Multi-layer neural network to analyze and orient data based on different position variables to determine the direction of the layers' inclination. Aspect As evidenced by the model of the slope of layers in South Sinai Figure (14).

Analogue Neural Networks:

These networks use analogical processes to analyze data and determine relationships between different variables. Analogue neural networks are used in areas such as digital photography, object and geographic landmark recognition, and sound analysis, where they can Use it also in determining the direction of inclination of rock layers (Figure14) based on positional variables.

Deep Neural Networks:

It represents an advanced type of neural network Figure (16) it Consists of many layers and modules.These networks rely on learning automatic programming to analyze data and identify the most complex relationships. And it cans Use Deep neural networks to achieve superior performance in identifying direction Layering tendency and understanding complex relationships between variables.

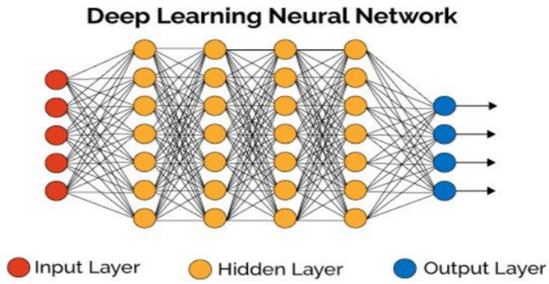

Figure (16): Deep learning neural network used in analyzing regression models, layer slope direction, and digital elevation models.

Source: website, Geeks for Geeks

The researcher points out the importance of using analogue neural networks to determine the direction of layer inclination in aerial and space photography images. When taking an aerial photo of a specific area, such as the Sinai Peninsula in general, and the case of the study area in particular (South Sinai), an analogue neural network can be used to analyze the image and determine the direction of the inclination of the layers in the area. For example, but not limited to, if the image shows a mountainous region, as is the case in the southern Sinai Peninsula region, the analogue neural network can determine the direction of inclination of the rock layers in the mountains, and also determine the degrees and elevations of the region, as is the case in the southern Sinai region.This can be said to be a very useful description Analyze the composition of the Earth, and understand the formation of the region.

The proposed code for designing a neural network is used in modeling the slopes of the southern Sinai Peninsula:

Creating aNeural Network in Python

This code explains the main steps and technical details for designing and training a neural network. The first part of this code explains how to define and configure the proposed neural network. Using Keras, TensorFlow. As follows:

1- **The first part of the proposed code for designing a neural network to model and analyze the slopes of the South Sinai Peninsula Governorate:**

```
from tensorflow import keras
from tensorflow.keras import layers
# Definition of neural network
model = keras.Sequential()
# Add network layers
model.add (layers.Conv2D (32, (3, 3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
# Define the loss function and optimizer
model.compile (optimizer='adam',
loss='categorical_crossentropy',
metrics=['accuracy'])
# Network training
model.fit(train_images, train_labels, epochs=5, batch_size=64)
```

2- The second part of the proposed code for designing a neural network ANN To builds and analyzes a regression model for the South Sinai Peninsula Governorate:

This code contains full details of all steps of building and training a neural network, including loading and processing data, dividing the data for training. And the test defining the detailed structure of the neural network, defining loss functions, optimizers, and performance metrics, training and evaluating the network, and using the trained network for prediction.

```
# Import required libraries and packages
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers, losses, metrics, optimizers, callbacks
import numpy as np
import rasterio
from sklearn.model_selection import train_test_split
# Download satellite data and digital elevation models
satellite_data = rasterio.open("satellite_images.tif")
dem_data = rasterio.open("digital_elevation_model.tif")
# Process data and convert it to matrices
X = np.array(satellite_data.read(), dtype=np.float32)
y = np.array(dem_data.read(), dtype=np.float32)
# Split data into training and testing
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)
# Definition of neural network
model = keras.Sequential()
# Add CNN layers
```

```
model.add(layers.Conv2D(32, (3,3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3,3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3,3), activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(1))
# Set loss functions, optimizer and performance metrics
model.compile(loss=losses.MeanSquaredError(),
optimizer=optimizers.Adam(),
metrics=[metrics.MeanAbsoluteError()])
# Neural network training
hist = model.fit(X_train, y_train,
validation_data=(X_test, y_test),
epochs=10, batch_size=32)
# Evaluate network performance on test data
test_results = model.evaluate(X_test, y_test)
print(test_results)
# Use the trained network for prediction
y_pred = model.predict(X_new)
```

After conducting many experiments and training on neural networks, the researcher discovered that they could be used in the geographical field, and modeling data (DEM, SL, AP, Geology.) in order to provide Adjust The model, and reaching the ideal architectural structure of the neural network that will provide the highest possible accuracy in modeling the regressions of the southern Sinai Peninsula region. He has risen the researcher chooses several artificial neural network designs, and compares their performance on the training data and the choice this is to reach the best model.Therefore, the researcher conducted many experiments the choice Evaluation and comparison in order to adjust the neural network better, more accurately and optimally before extract the final form and final model.

The researcher worked on designing and developing the proposed network to model South Sinai regression, where he collected and prepared satellite data, and the necessary digital elevation models, and then experimented with several different neural network architectures such as CNN, Auto encoders. The researcher also trained the different models and evaluated their performance on the selection data, then chose the best initial model and started improving it, and then applied techniques such as maintaining the best models and adjusting the parameters in order to increase accuracy. Finally, the researcher tried as much as possible His ability taking the time to test many different artificial network architectural structures, in order to reach the best possible performance of the network proposed in this research. After completing all this, the researcher settled on the final architectural structure of the network proposed in geographical studies and in the environment.GIS, RSas follows:

1- The proposed and used network is the regressive neural network. (Convolutional Neural Network).
2- Regressive layers with activation functions4 Relu
3- My class PoolingTo reduce the size of the matrix
4- flat layer (Flatten)
5- Two layers density (Dense)
6- loss function(MES) Mean square error
7- Mohsen Adam (Adam)

Applying the data of this model of networks showed the highest accuracy on the data the test Compared to other architectural structures that were chosen.

The proposed final architectural structure for an artificial neural network for regression modeling for application to the South Sinai region:

1- **Inputs** it can include satellite images and digital elevation models.

2- **regressive layers**:

- The first regressor layer contains 32 regressor filters (3X3) with activation function ReLU.
- The second regressor layer contains 64 regressor filters (3X3) with activation function ReLU.
- The third regressor layer contains 128 regressor filters (3X3) with activation function ReLU.
- The fourth layer contains 128 regression filters (3X3) with activation function ReLU.

3- **pooling layer**:These layers contain the following:

- Pooling layer "1" reduces the dimensions by half (2x2)
- Pooling Layer2 Reduce the dimensions by half (2x2)

4- **density layers (Filly Connected)**:

These layers contain the following:

- First density layer: 64 unit's with ReLU.
- Second density layer: one output unit.

5- **Loss functions and optimizer**:These layers contain the following:

- (MSE)The loss function is the mean square error.
- (Adam) Mohsen Adam.

Types of neural networks used in analyzing aerial photos and satellite imagery:

The researcher will focus on studying some neural networks, due to the multiple networks its tasks its role is unparalleled in geographical studies, which confirms the strong relationship in the positive and future evolutionary direction between geography and artificial intelligence applications, as will become clear later in the lines.next.

We will start by studying neural networks used in analyzing geological maps and digital elevation models DEM, slopes, aspect, and contour models with a simplified application to clarify the importance and relationship to South Sinai Governorate as follows:

Many artificial neural network algorithms are used in analyzing and studying geological maps, the most important of which are the following:

(1) Convolutional Neural Networks:

These networks are used in Analysis of aerial photos, satellite imagery and geological maps and that to extract Geological landmarks and structures for the research and study area, it also features African layers that circumvent input data to extract basic features.(Nielsen ,M., 2016, pp.131) as analyzing geological maps is extremely important in the field of geology, as it depends on analyzing and understanding the structure and characteristics of the earth and its various geological formations. In recent years, convolutional neural networks have been used Convolutional Neural Networks It is widely used in analyzing geological maps, due to its ability to deal with complex data and predict the geological structure of the Earth.

The role of convolutional neural networks in analyzing geological maps is illustrated as follows:

- **Rock classification:**

Maybe Use Convolutional neural networks to classify the different types of rocks present in the geological map. These networks learn from previous models and are used to determine the type of rocks based on available geological information such as the chemical composition and physical properties of the rocks.

- **Prediction of geological structures:**

Convolutional neural networks are effective in predicting geological structures such as stratigraphy and slope and the cracks. These neural networks can also analyze available geological data and enhance understanding of the internal structure of the terrain.

- **Adapting to changes in data:**

Convolutional neural networks are characterized by their ability to adapt to changes in geological data. For example, if new data is added or existing data is modified, the convolutional neural network can modify its pattern to include these changes and improve the accuracy of the analysis.

- **Geological image analysis:**

Convolutional neural networks (CNNs) can be used in image analysis, geological mapping, and extracting geomorphological and terrain information. The network can distinguish between various patterns and elements in the image, such as mountains, valleys, and rivers, providing a comprehensive view of the terrain.

- **Improve accuracy of results:**

By using convolutional neural networks, the accuracy of geological map analysis can be improved, which contributes to improving our understanding of the geological structure and our expectations of different terrains.

How to build convolutional neural networks used in geological map analysis:

Convolutional neural networks accept vector images or features input into an image (one input node per input) to the convolutional neural network, which transforms them through a series of hidden layers.Hidden Layers, usually using Nonlinear activation functions.

Each hidden layer also consists of a group of Cells Neuronal, where each neuron is fully connected to all neurons in the previous layer.Figure (17)

The last layer of the convolutional neural network (i.e. the output layer) outputIt is fully connected and represents the final output ratings of the network.

A diverse data set is essential for training CNN and understands the different types of classes Figure (17) by training the network on the dataset, we can observe how Extract Each layer has features and contributes to the final prediction. (Rosebrock, A., 2021), a convolutional neural network can be used (CNNs) which takes advantage of the structure of the input image and defines the network structure in a more logical way. Unlike a standard neural network, where layers are arranged CNN In three-dimensional size 3D (width, height, and depth) where depth refers to the third dimension of Volume, such as the channels in an image or the number of filters in a layer.

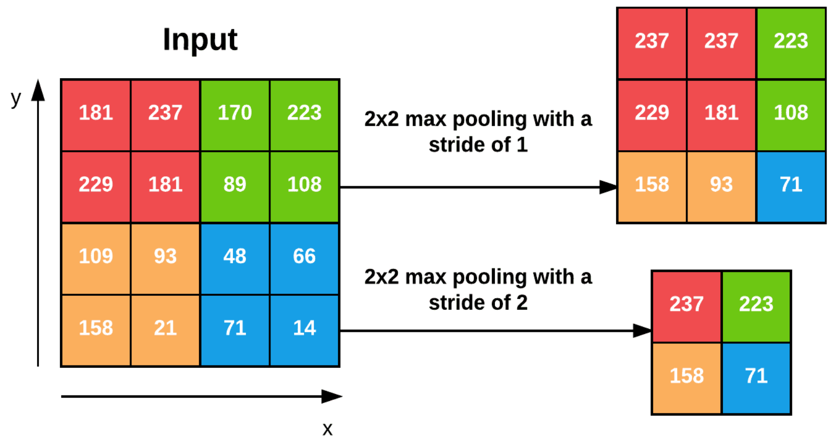

Figure (17) Convolutional neural networks and types of layers

Source: link, https:images.app.goo.g1|Azgxbwptz7

To make the previous example more specific, we must once again consider the data set CIFAR-10 The input size will have dimensions of 32X32X3 (width, height and depth) respectively. The neural network cells in the subsequent layers will only be connected to a small area of the layer before them. This is instead of the fully connected architecture of a standard neural network. And we call this by calling Local, which enables us to provide a large amount of parameters in the network. Finally, it will be the output layer output Size 1x1 xs N, which represents the image distilled into a single vector of class scores in the case of CIFAR-10.

Types of layers:

There are many types of layers used during convolutional neural networks to analyze images and geological maps, including convolutional (CONV), activation (ACT or RELU), where we use the same activation or actual function.and aggregation (POOL), fully connected (FC), batch normalization (B.N) and leakage (DO).

Caused by a string jam who is this Layer in a mesh-defined manner CNN usually are used Simple text schemes for description<=FC <=RELU <=CONV <=INPUT: CNN-SOFTMAX.

We specify here a simple CNN. It accepts inputs related to the geological map, slope, slope direction, digital elevation model, or other inputs, and applies a convolution layer, followed by an activation layer, and then a fully connected layer. Finally, the Softmax classifier provides the output classification probabilities. The activation layer, often Softmax, is sometimes omitted from the network diagram where it is supposed to follow the final fully connected layer directly.

Convolutional layers:

layer CONV she Labneh the basic For the network Nervousness gyrus.Composed Parameters layer CONV from group from Filters The midwife To learn K, where He is for every candidate an offer And high, And it is always Square z. And this Filters Small (from where its dimensions Spatial) But it is Stretching via Depth the complete for size. With regards for input to CNN, the Depth he number Channels in Image (any Depth three when the job with photo RGB, one for every channel).with regards for sizes the deepest in the network, Will be Depth he number Filters applied in Class Previous.

To make this Concept more clearly, We Invited We take in Consideration the passage Front For CNN, where We collect all Filters Kvia an offer And high size

Input.Simply put more, We can Thinking in sliding all grain from Beads Kvia region input, And computerization to hit from where Elements, and assembly, then storage value Al Kharj in a map Energizing Bi Dimensions, as he adverb in the Figure (18).

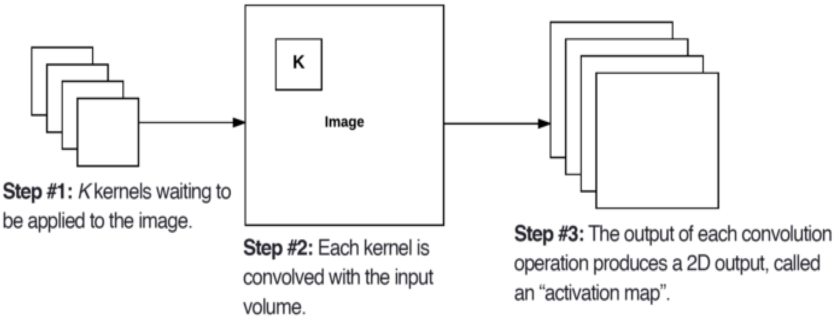

Figure (18) the left in each convolutional layer in CNN There are beads KApplied to the input volume, the center of each grain K Combined with the input volume; each kernel produces a 2D output, called an activation map.

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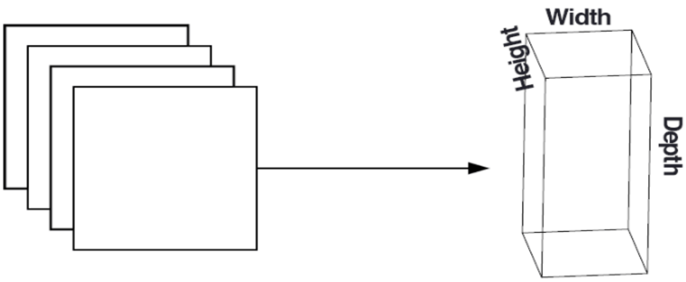


Figure (19) after obtaining the activation maps K They are stacked together to form the input volume to the next layer in the network

Source: link, https:images.app.goo.g1|jdL2GZegQpTn5xcy7

(2) Networks Correlation Self: Autoencoders

Based on the topographic, geological, geomorphological, and climatic Nature of the southern Sinai Peninsula. Networks can be used Correlation Self

Autoencoders To analyze and summarize data accurately and make predictions about natural changes and the future Figure of the region. This can be applied to the South Sinai region as follows:

1- Data preparation:

The textual geographic and geological data is first converted into a Digital representation that can be processed using machine learning. Where natural language processing techniques can be used NLP to encode texts into numbers or vectors.

2- Self-connection network training:

The network is then trained on digital data, and then the converter part (Encoder) with recovery Original data from compressed representation, then the network is trained to minimize the difference between the original and restored data.

3- **Terrain and geomorphology analysis And geology** Once the network is trained, where it can Use The resulting compressed representation can be used to analyze the features of the terrain, geomorphology and geology of the South Sinai region, for example Use This representation is used to identify areas with high elevations, rugged terrain, or dominant rock types.

4- Natural changes can be predicted in South Sinai. Where can Use this is a network Correlation Trained self to predict future natural changes. For example, historical data and current data can be used to factor in changes in coastlines, movements of rock masses, or the formation of new valleys as a result of climatic or geological factors.

5- Evaluating the future shape of the area. And that using previous predictions and analyses, where it is possible to evaluate the future Figure of the South Sinai region and how its geographical and geological characteristics may change over time. This information is useful for urban and infrastructure planning, environmental protection and natural resource exploration.

Through these steps that the researcher specified in his research, it becomes clear that networks Correlation It is considered a powerful tool for analyzing and summarizing complex geographical and geological data, predicting future natural changes, and obtaining a better understanding of the shape of the southern Sinai Peninsula region.

Self-connecting networks can be used: AutoencodersIn forecasting coastline changes along the Gulf of Aqaba in eastern South Sinai over the next ten years, where we can Use network Correlation to achieve this through several steps as follows:

1- data collection:

At the beginning of the project, the user must collect historical data on the coast lines in the study area (Gulf of Aqaba) for previous years, in addition to current data. This data may include satellite imagery, topographical surveys, and geological data on rock types and geological formations in the area.

2- Data preparation:

This stage includes encoding the data into a digital representation that Can Be processed by deep learning networks Deep Learning For example; satellite imagery can be converted into digital matrices.

3- Self-connection network training:

Even it's happen at this stage training network Correlation Self-prepared digital data.Then he gets up Adapter part (encoder) converts the data into a compressed representation, while the disassembler part will try (Decoder) Data recovery Original From compressed representation.

4- Coastline analysis bay Current obstacle:

After network training Correlation self, is used compressed representation of current data for analyzing current coastlines in the Gulf of Aqaba region. This will help us understand the current dynamics of the coast and how they are affected by various geographical and geological factors.

5- The role of artificial intelligence in predicting coastline changes:

Using a compressed representation of historical and current data, the network can predict how coastlines will change in the future based on Model AI and trends learned. These predictions can be made for different time periods, such as (5 years or the next year).

There are many types Artificial neural networks that can be used to predict coastline changes in programs such as ArcGis and Erdas Imagine One of the most important networks is back propagation networks, which are the most common types of networks And in use It consists of multiple layers of neurons and uses a backward learning algorithm for training.

There are also support vector networks (Support Vector Machines - SVM) these networks are used to solve classification and prediction problems. It relies on the idea of specifying an interval level such that the distance between the data points and the interval level is maximum. There are also feature maps networks (Organizing Maps-SOM These networks are used to classify data and identify patterns in it. They work to reduce the dimensions of the data while preserving the topological relationships between points. Finally, there are recurrent neural networks (Recurrent Neural Networks-RNNsThis type of network is used to process sequential data such as word or video strings, and is characterized by its ability to remember previous information during the input processing process.

The network type is chosen based on the nature of the problem and the characteristics of the available data. In the case of predicting coastline changes, it is likely to use back propagation networks or support vector networks because they suit the problems of prediction and geospatial classification. (Walid Muhammad Ajwa, 2024) The figure shows (20) the importance of artificial neural networks ANN Especially, artificial intelligence AI General in identifying and predicting the development of coast lines.This can also be applied by adding a tool or application (DSAS) Digital Shoreline Analysis System Version 5.1 User Guide, through the website USGS (US Geological Survey). And count (DSAS) is one of the main tools used to analyze the evolution of coastlines, and it is likely that it uses a set of artificial intelligence algorithms AI And machine learning "M.L" To predict changes in coastlines, the most prominent of these algorithms are (backpropagation networks, regression algorithms, automated support vectors, hidden Markov chains. Markov Models And genetic algorithms Genetic Algorithms and may are used a tool (DSAS) one or a combination Who is this Algorithms based on the nature of the available data and the accuracy of the predictions required for the development of coastlines in any region of the world, including the case study, the southern region. Same Sinai, which the researcher used to emphasize the role of artificial intelligence and neural networks in emphasizing the features of aerial photos and satellite imagery.

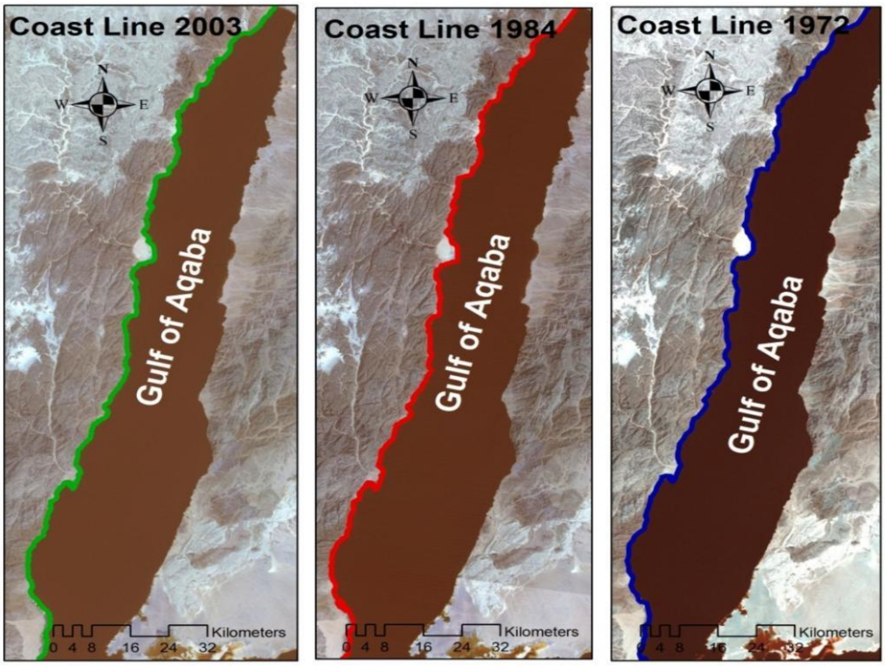


Figure (20) Evolution of the Gulf of Aqaba coastline between 1972, 1984 and 2003 as one of the most important features of space visuals LandSat MSS, TM, ETM

Table (1) Evolution of the Gulf of Aqaba coastline between 1972 and 2003

Time period	1972 to 1984	1984 to 2003
Development value in metres	376	182.51

Source: Researcher using a program Erdas Imagine 9.3, Arc Map10.3

Applying to the case study (South Sinai), it is clear from monitoring the development of the coastline of the Gulf of Aqaba Table (1) east of the region that the coast has developed and advanced on land during the time period between 1972 and 1984 AD at a rate of about 378 metres, and this may be due to the narrow coastal plain and the mountainous back of the region. The plain almost disappears in many areas due to the mountains over looking the coast directly. Figure (21) Also, the change in the surface level of the Red Sea may be a result of global warming and human activities such as the development of tourist areas and pollution, which affects the dynamics of the coast. While the rate of movement of the coastline decreased in the period between 1984 and 2003 AD, reaching about 182.51 meters, and this may be due to the nature of the geological region, climate changes such as winds, waves, and sea currents that play a role in transporting sediments and forming the coastline.

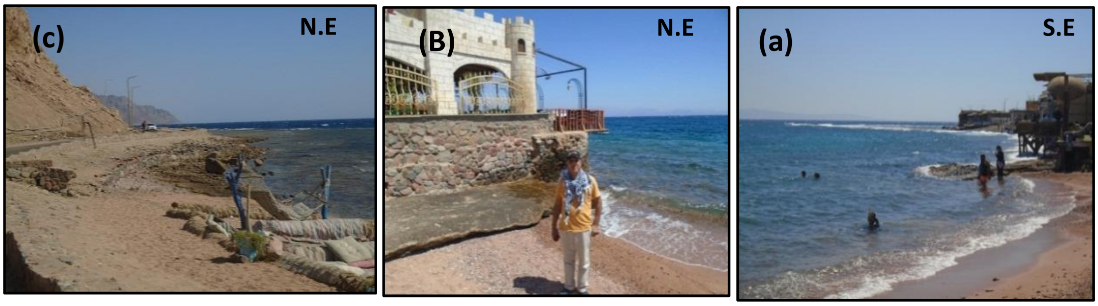


Figure (21) **the development of the coast of the Gulf of Aqaba east of the Sinai Peninsula**

We notice from pictures (a, b) the extent of the development of the coastline, as it advanced towards the tourist facilities in the region and became threatened with disappearance from its location in the future, as is evident from picture (c) the disappearance of the coastal plain due to the mountainous back, noting that The Red Sea expands annually at a rate of 2.5 cm as a result of the divergent tectonic movement between the Arabian Plate and the African Plate, in addition to the role of climate change, although its impact on the Red Sea coast is less severe than before. Its effect On the Mediterranean Sea.

6- Evaluation of results:

After obtaining the predictions, we assess their accuracy by comparing them with the available ground truth data.

The accuracy of predictions can be improved by training the network on more data or modifying its structure. This example provided by the researcher illustrates the importance and role of artificial intelligence general, and neural networks in particular, as it cannot We mention Learning Automatic Machine Learning Not to mention artificial neural networks ANN Artificial neural networks are the main part of…Machine Learning, which achieves learning Learning That is, theNeural Networks It serves as the basic engine of the entire system. (Ajwa, W.M., 2024, p. 223)

Until it becomes clear how important and role the self-correlation network is in analyzing the complex geographical and geological data of the Sinai Peninsula and predicting important natural changes such as changing coast lines, a similar approach can be applied to other analyzes such as studying the movements of rock masses, sand dunes, i.e. dynamic phenomena in general, or the formation of Valleys, or other geographical and geological phenomena in the region.

There are also many artificial neural networks that are used It is greatly useful in geographical and geological studies, including the following:

Backward neural networks Convolutional Neural Network, and recurrent networks Recurrent Neural Networks Accreditation networks Graph Convolutional Networks, Clustering algorithms Cluttering algorithms, and deep input networks Deep Belief Network, which extracts complex patterns from drilling and geophysical survey data. Support vector networks are also important networks in geographic studies, especially physical geography, through which it is possible to classify and identify types of rocks and geological formations. Algorithms are alsok – means to collect and classify geochemical data into similar groups of important networks.

There are networks known as Bayesian networks Bayesian NetworksIt is used to model probabilistic relationships between geological and geomorphological phenomena and events. And other neural networks and algorithms that are used in geographical analysis, modeling, measurements, studying relationships, predictions, etc. This emphasizes the role of neural networks in geographical studies, especially physical geography, which is the basis for human geography.

Artificial intelligence techniques used in classifying satellite visuals, extracting features, and deriving data:

Classification of aerial photos and satellite imagery is a Figure (22) is an important application of artificial intelligence and neural network analysis. This is followed by one of the areas of artificial intelligence, which is computer vision and techniques, Machine Learning, in order to extract image features. The researcher applied this through a program Erdas Imagine Where the researcher made an undirected classification unsupervised Classification For satellite images LandSat Mss 1972, TM 1984, after work Layer Stack For items, learn about working algorithms Layer Stack like Layer Stack Algorithm, Image Subset Algorithm, Model Maker These algorithms were used to combine and assemble the various elements of satellite images into a program Erdas Imagine.

The neural network used in the work Layer Stack For bands The images used in classification, as well as in analysis and monitoring of environmental changes and monitoring of land use changes, generally consist of simple processing elements that work to implement simple functions, and the behavior of the network is generally determined from the use of these networks to integrate and analyze multiple data used in geographic information technology, such as Erdas Imagine.

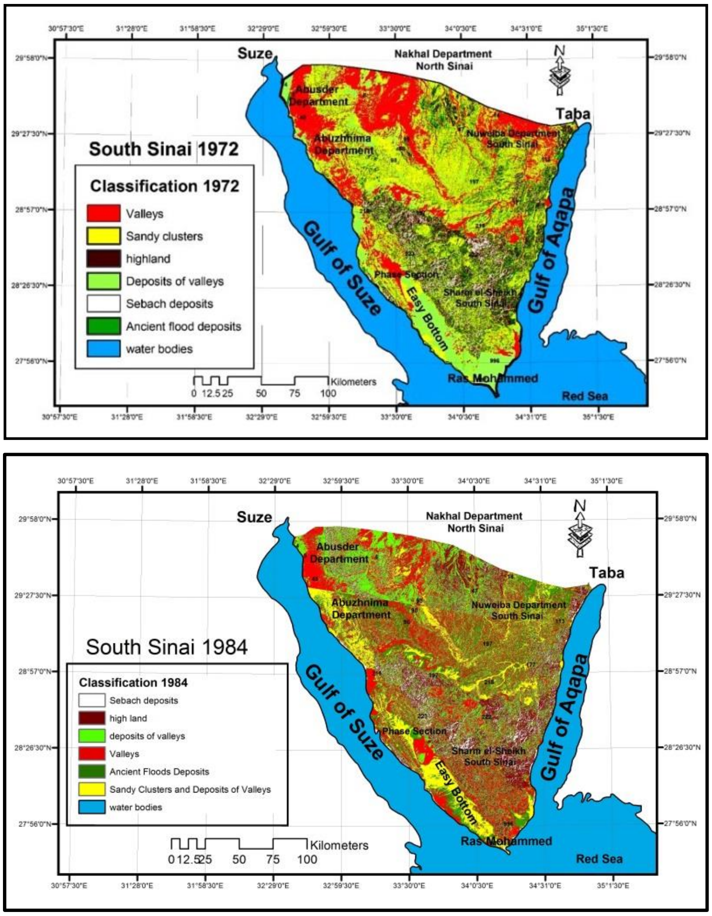


Figure (22) **Classification of satellite imagery to extract image features, with techniques Machine Learning & Computer Vision**

The algorithms used to classify geomorphological phenomena from satellite imagery are divided into two common methods, which are as follows:

1- Artificial intelligence techniques in supervised classification: (Supervised Classification)

It is used in this type of classification and extraction of features of aerial and satellite images using a program Erdas Imagine Nearest neighbor algorithms (Nearest Neighbor), where this algorithm calculates the distance between a data point, for example (pixel values) and the landmark points in the training set. The point is classified into the class to which the closest trained point belongs the nearest neighbor algorithm is characterized by its simplicity and speed in classification, but it lacks the ability to handle nonlinear data well. Therefore, more complex algorithms such as artificial neural networks are often used for classification in more complex cases. (Remote Sensing Digital Image Analysis Richards, 2013-chapter 9It is one of the common algorithms in classifying multispectral space visuals, as it depends on the spectral distance between the values of Pixels In space data, the values ofpixelsIn the data set for each category. The pixels to category (Training Data) The parameter that contains the nearest spectral model in the distance. The mathematical formula for calculating the spectral distance in the nearest neighbor algorithm is as follows: d= $\sqrt{}(\sum(Ri - Si)^\wedge 2)$(Duda, r.o., Hart, P.E., Stork, D.G.2001)

Wher edis the spectral distance, Riis the channel value, I For pixels in space data, and SiIt is the value of the channel i for the spectral model in the parameter data set.

The nearest neighbor algorithm is characterized by its simplicity and speed in classification, but it lacks the ability to deal with nonlinear data well. Therefore, more complex algorithms such as artificial neural networks are often used for classification in more complex cases.

The machine support function (Support Vector Machine) is one of the important algorithms for classifying and extracting features of aerial photos and satellite imagery using machine learning, as this function seeks to find the best dimensional separator that separates classes in the multi-dimensional feature space. This function also tries to maximize the margin between classes.

This algorithm is also one of the most important machines learning algorithms Machine Learning In classification of multi spectral satellite data. This algorithm searches for the best dividing line (super-level) to divide data sets into different

categories in a multi-dimensional attribute space. This dividing line is determined such that the dimension represents the closest data point from each category and the dividing line is the limit.Al-Aqsa (maximum margin) This algorithm can be expressed as:SVM With the following function:F (x) Σ (αi * yi * K(xi, x) + b
Where yi it is the target value of the data point xi, and kernel (xi, x) k it is a similarity function that defines the relationship between two data point sxi And xIn space ai and b these are the parameters that are learned from the data. (Book Pattern Recognition and Machine Learning", Christopher Bishop, Chapter 7, on machine support) and one of the most important features of this function is its ability to deal with non-linear data through Use Various kernel functions such as linear kernel, radial kernel, and exponential kernel. (The official user guide for the program Erdas Imagine, Chapter on “Classification Algorithms).

2- Artificial intelligence techniques in unsupervised classification:

Prepare Unsupervised classification is a learning technique Unguided machine Where data is divided into groups (clusters) based on their intrinsic characteristics without prior knowledge of the categories, algorithms such asK-Means, AndISodataAnd others in this type of classification. (Ajwa, W. M., 2024).

The researcher identified a close relationship and interconnectedness among unsupervised classification, machine learning, computer vision, and artificial intelligence in the processing of multispectral satellite data and other remote sensing applications. Remote sensing classification of spatial data is a primary application of machine learning, utilizing both supervised methods such as neural networks and support vector machines, and unsupervised methods such as clustering algorithms. Machine learning algorithms enhance the efficient extraction of information and patterns from large datasets. Computer vision plays a crucial role in analyzing and extracting image features from multispectral satellite data. Techniques such as pattern recognition, image classification, and object tracking are employed to extract spatial and spectral information from satellite imagery and aerial photos (Ajwa, W. M., 2024).

"It is recognized that machine learning and computer vision are fundamental branches of artificial intelligence. Artificial intelligence techniques such as artificial neural networks (ANN), fuzzy logic, and evolutionary algorithms are employed in numerous space data processing applications, including classification, tracking, and the extraction of image features and information (Ajwa,W.M, 2024, p. 378).

3- Analyzing classification maps and deriving data using applications Copilot, And Claude.ai

It is evident from trying to use an application Copilot Powered by Chat Gpt.4 Where he works CopilotIn the field of advanced artificial intelligence, which includes machine learning techniques And natural language processing These techniques enable the program to understand texts and images and generate responses that suit different questions and requests.

It has been shown by using this application Copilot the map of the classification of geomorphological units of the southern Sinai Peninsula during the years 1972 AD and 1984 AD. The maps show the distribution of phenomena through the distribution of the set of colors that represent each phenomenon on the map during the study period, and that each color indicates the area of each phenomenon separately, but without the program being able to determine Spaces. While program and application analytics indicate Claude.ai which belongs to a domain Natural Language Processing It is the branch related to developing models and algorithms to understand, comprehend and produce human natural languages. The researcher noticed that this application is becoming more important day after day, with the continued progress in the field of artificial intelligence, as its ability to analyze and generate Results are consistent It is a strong competitor to Chat Gpt-4 Strongly. The application of this program in analyzing the maps produced from Satellite Imagery Analysis of the study area has shown that it is much better than…Copilot Supported by Chat gpt-4As it turns out from the analysis Claude.ai For classification maps Figure (22), Table(2) ,the following:

Regarding the classification map in 1984 AD, the application indicates that the flood deposits in red on the map cover a large area, especially in the western regions of the southern Sinai Peninsula, and the valley deposits that are represented on the map that was produced with the program Erdas ImagineIn yellow, it is spread in separate areas, but in smaller areas. It was also evident from the analysis of the application and program Claude.ai the Mountain deposits, which are represented on the map in light gray, appear mainly along the edge of the Gulf of Suez. While the mountainous areas, which are represented in dark red, are concentrated in the eastern regions, which are the highest and most rugged. pointed out The application indicates that the water bodies are represented in blue, which are the Gulf of Suez and Aqaba, the eastern and western borders of the South Sinai Peninsula Governorate.

As demonstrated by the analysis of the classification map in 1972 AD for the case study in the south of the Sinai Peninsula through the application and the researcher's work With a test The results are that the valleys that appear on the map in red are mainly located in the eastern regions near the Gulf of Aqaba, and the sand clusters in yellow appear in separate areas. While there is a great similarity in the distribution of mountainous areas in brown on the 1972 AD map and the 1984 AD classification map, this seems logical and confirms the accuracy of the analysis with this application.Claude.aiIt was also shown that the valley sediments that appear in light green on the 1972 AD map are concentrated near coastal areas.

The results also indicate the extent of similarity between the years 1972 and 1984 AD in the distribution and areas of ancient flood deposits, which appear on the map in dark green.

Table (2) Colored areas for classifying natural phenomena in the south of the Sinai Peninsula during 1972 AD and 1984 AD

Phenomenon	**1972**	**1984**
	Area %	**Area %**
Dry Valleys	23	12
Elevated Lands	13	21
Sand Aggregates	21	23
Sabkha Deposits	7	9
Valley Deposits	21	11
Ancient Flood Deposits	23	1
Total	100	100

Source: The researcher using artificial intelligence application and techniques (Claude.ai), and verify the data using a program ArcMapGis10.3

The analysis of the data in Table (2) highlights the significance of utilizing geomorphological classifications and data extraction from aerial photos and satellite imagery through integrated artificial intelligence techniques, remote sensing technologies, and geographic information systems (geospatial artificial intelligence) in understanding geomorphological changes and land development over time. This approach enhances the understanding of ancient and modern land formations in this vital and strategic region of Egypt.

The data in Table (2) indicate significant changes in the distribution of areas between 1972 and 1984. There are noticeable changes in the proportions of areas occupied by dry valleys, elevated lands, sand aggregates, sabkha deposits, valley deposits, and ancient flood deposits in the region during the analysis period from 1972 to 1984.

These data can be used to analyze changes in terrestrial environments, enabling the use of artificial intelligence techniques such as machine learning, computer vision, and artificial neural networks to gain a deeper understanding of these developments.

These techniques contribute to providing accurate insights into geomorphological changes, aiding in improving land management and development strategies in the future.

3-Artificial neural networks:

Neural networks work excellently in processing images in general, aerial photos, and satellite imagery in particular, as they rely on image analysis And extract Features And derivation Information includes many of the artificial neural networks used in this matter, as image analysis depends on the type of neural network and the different architectures that are used; But in general, networks consist of different layers of units Computational neurons are connected to each other by certain weights.

And it has I depend Researcher on the program Erdas Imagine The program contains and uses many algorithms in classifying satellite imagery and visuals, including those mentioned aboveK−Means And hierarchical division Hierarchical Clustering Which creates a hierarchical structure of groups where all views start in one group and are then gradually divided according to similarity levels.

Analysis algorithms are also prepared Series Agg omerative Hierarchical Clustering One of the important algorithms in analyzing and classifying aerial images and satellite visuals, where it begins with all Watch in an independent group, then gradually merge similar groups until you reach one group. (Duda, R. O., Hart, P. E., & Stork, D. G., 2012).

Monitoring environmental changes and changes in land use:

Environmental changes and changes in land use are considered a Figure of (23) It is important to assess the state of the environment and sustainable development.

Technologies such as low frequency radar can also be used to detect changes under the earth's surface. And field surveys, where field surveys are conducted to assess the state of the environment and biological diversity, and collect soil, water and air samples for analysis. Geographic information systems programs are also used to analyze spatial data and descriptive data to monitor changes over time.

There are several ways to monitor changes the most important of them Remote sensing, where possible Use Aerial photos and satellite imagery, in order to monitor changes in Use Land such as urbanization, deforestation, desertification, etc.

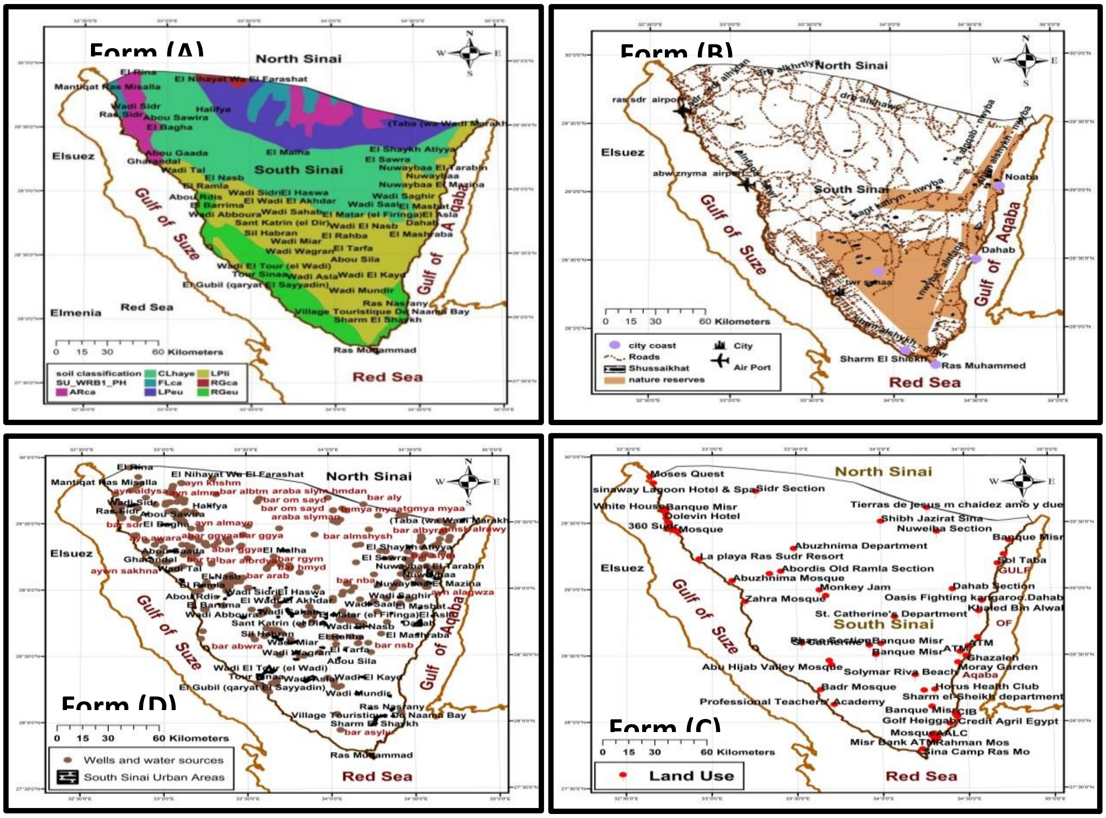


Figure (23) Land Uses (B, C, D) and Soil Classification (A) Southern Sinai Peninsula Governorate

Monitoring stations are installed to monitor pollution levels in the air and water continuously.Changes in biological diversity are also monitored by studying plants, animals, and ecosystems. Community participation is an important way to monitor environmental changes, as local communities can be involved in the monitoring process through participatory monitoring programs. The success of monitoring environmental changes depends on coordination between different parties, and the availability of financial and human resources. And use Effective modern technologies. Monitoring results must also be translated into policies and procedures to preserve the environment and ensure sustainable development.

Artificial neural networks (ANNs) play a crucial role in monitoring environmental changes in the Sinai Peninsula, evident through the analysis of big data derived from remote sensing and Geographic Information Systems (GIS) techniques. The use of ANNs in this field can be structured through the following steps:

1- Data collection:

Multi-spectral and multi-temporal remote sensing data for the Sinai Peninsula are collected from various satellites such as LandSat, Sentinel and others.

2- Data processing:

The raw data is processed through geometric correction and radiometric, supervised and unsupervised classification of images, and extract spatial information.

3- Neural network training:

Where the artificial neural network is trained using part of dataTreating as input the actual data of environmental changes as desired output, learning algorithms such as inverse error propagation are used to train the network to recognize patterns of environmental changes.

4-**Network test:** Complete a test Trained network using Data a test independently to verify its accuracy in predicting environmental changes.

5- The application after checking the network accuracy:

Maybe Use it to monitor environmental changes in the Sinai Peninsula continuously by analyzing new remote sensing data.

Artificial neural networks are characterized by their ability to deal with non-linear and complex data, learn from the data and identify patterns, which makes them a powerful tool for monitoring complex environmental changes in regions such as the Sinai Peninsula in general, and South Sinai Governorate in particular. (Mas, J.F., & Flores, J.J., 2008, P.617).

By studying the characteristics of the southern Sinai Peninsula region, a multi-layer artificial neural network can be proposed to monitor environmental changes and land use in the southern Sinai Peninsula governorate. (Adeloye,A.J.,Rustum,R.,& Kariyama, ID9 "2012" Neural computing modeling of the reference crop evaportranspiration at low, Osum State Nigeria.Journal of King Saud University-Engineering Sciences, 24(1), (81-91) A network can be designed (Multi-Layer Perceptron-MLP).As follows:

1- input layer:

Includes digital elevation data (DEM) for mountainous terrain. And climate data (temperature, precipitation, humidity, etc.). As well as geological data on rock types and previous land uses.

2- Hidden Layers:

Includes These hidden layers depend on the number of hidden layers and the number of neural units in each layer, Complete Determined empirically depending on the complexity of the data. It can also be used Careers activation such as the radial network (ReLU or tanah salihiya). (TanH)

3- Output Layer:

Include categories Use Different lands (urban, agricultural, mountainous, desert, etc.). And indicators of environmental changes (desertification, removal of vegetation, erosion, etc.) and the neural network are trained. Using A portion of known data to learn relationships between inputs and desired outputs. The network is then selected on independent testing data to verify its accuracy.

After training and testing the network, it can be used to monitor environmental and land use changes in South Sinai. Continuously By analyzing new remote sensing data and other relevant data. It is also important to perform data pre-processing operations such as geometric and radiometric correction and noise removal in order to improve the performance of the neural network.

Below is the code Python using library keras to design the proposed neural network to monitor environmental changes and land use in the South Sinai Peninsula Governorate.

```
import numpy as np
from keras.models import Sequential
from keras. layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D
from keras.optimizers import Adam
#Determine input dimensions (according to remote sensing data
and others)
input_shape = (n_bands, rows, cols)
#Create a neural network
model = Sequential()
#Input layer
model.add(Conv2D(32, (3, 3), activation='relu',
input_shape=input_shape))
model.add(MaxPooling2D((2, 2)))
model.add(Dropout(0.25))
#Hidden layers
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(MaxPooling2D((2, 2)))
model.add(Dropout(0.25))
model.add (Flatten())
model.add (Dense(128, activation='relu'))
model.add (Dropout (0.5))
#Output layer
num_classes = len (land_use_classes) +
len(env_change_indicators)
model.add (Dense (num_classes, activation='softmax'))
#Network assembly
model.compile (optimizer=Adam (),
loss='categorical_crossentropy', metrics=['accuracy'])
#Print network summary
model.summary ()
```

The following is an explanation of the code used:

1- The necessary libraries were imported from keras.

2- Determine the dimensions of the input (N-bands, rows, cols) According to the remote sensing data used.

3- Construct a multilayer sequential neural network model.

4- Input layer added using Conv 2D to deal with spatial data, it follows Dropout, And Max Pooling 2D to control excessive increase. (Overfitting).

5- It was completed Use layer Flatten to convert the output to a flat form before feeding it to the fully contact layer Dense.

6- Complete layer added Connection Dense with 128 nerve units and Dropout.

7- Output layer added Dense using Lands and the number of indicators Environmental changes to be predicted.

8- The network was assembled and the loss function and performance metrics were defined and processing.

9- The network summary is printed to display the number of layers and neural units and dimensions Inputs and outputs.

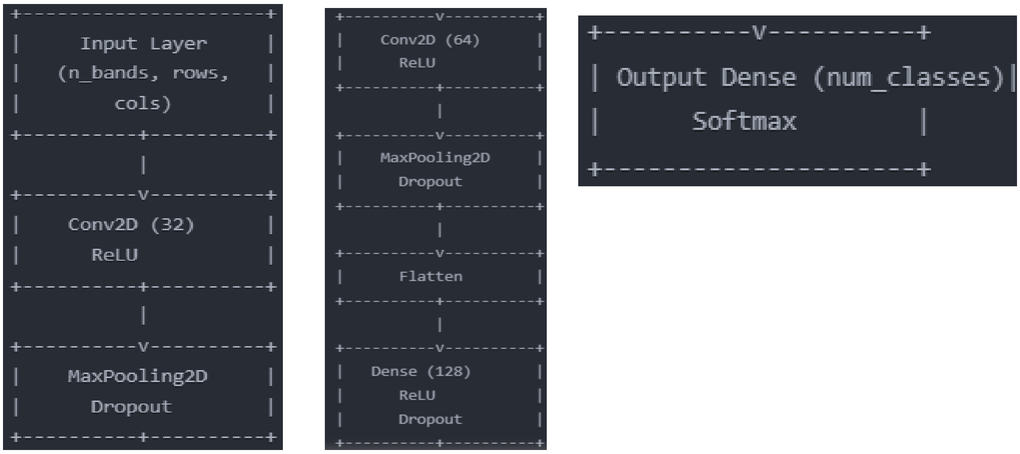
One of the important notes that must be made is Consideration the following:

- Values must be modified cols, rows, and n-bands Depending on the dimensions of the remote sensing data used.
- Must be specifiedenv – change – indicators, Andland-use –classes by Categories Use Land and environmental change indicators to be predicted.
- Can be modified Number of layers Hidden units, the number of neural units, and the types of layers depending on Needs Problem and network performance.
- After the network is compiled, it must be trained on the training data using .model.fit()

This application is a basic example of neural network design using...Keras, inpython This model can be used in all similar geographical studies, provided that it can be modified and improved, according to the special requirements of the problem of monitoring environmental changes and land use in the southern

Sinai Peninsula. Below is a drawing of the proposed artificial neural network to monitor environmental and land use changes in the southern Sinai Peninsula.

(A) (B) (C)



It is clear from the figure (A, B, C) the following:

1−Input layer takes remote sensing data and other inputs in dimensions (N−bands, rows, cols).

2−recursive embedding layer(Conv 2D) with 32 filters followed by the activation function ReLU

3−Layer Assembly Al−Aqsa (Max Pooling 2D and a projection layer) (Drop Layer) to control excessive increase.

4−Second recursive embedding layer (Conv2D) with 64 candidates and followed by ReLU.

5−Layer another max grouping and projection layer.

6−Flattening layer (Flatten) to convert the output to a flattened format.

7−Complete layer Connection (Dense) with 128 neural units, activation function ReLU.

8−Output layer (Output Dense) is equal to the number of nerve units Number of usage categories Land and number of environmental change indicators (num−classes), job Energizing Softmax for classification.

It is clear from all of the above that a multi-layer neural network consists of layers of recurrent embedding and maximum pooling for dealing with spatial data and communication layers for final inference. Projection layers have been included to prevent overfitting during training. It is noted that the number of layers, neural units, and types of layers can be modified according to the needs of the problem and network performance.

To monitor environmental changes in the research area, satellite images were downloaded from the US Geological Survey web site usgs Then he worked Layer Stack For Bands For the visuals used in the research, the algorithms used in the work have been identified Layer Stack in Layer Stack Algorithm, Image Subset Algorithm, Model Maker These algorithms were used to combine and assemble the various elements of satellite images into a program Erdas Imagine.

The neural network used in the work Layer Stack For bands The images used in analyzing and monitoring environmental changes and monitoring land use changes generally consist of simple processing elements that perform simple functions, and the behavior of the network is generally determined by using these networks to integrate and analyze multiple data used in geographic information technology, such as Erdas Imagine.

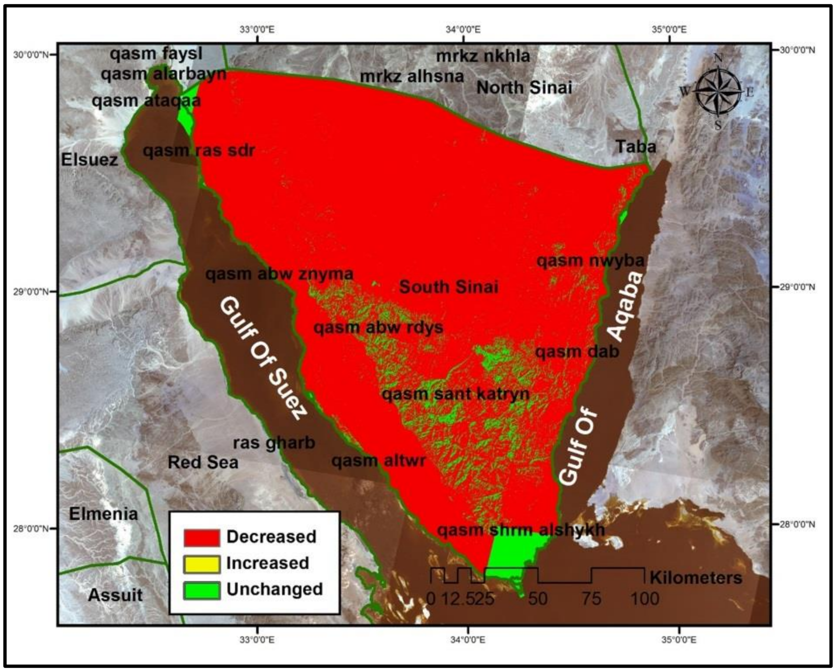


Figure (24) Change Detection in South Sinai during 1972|1984 Technology: Erdas Imagine, ArcMap GIS

Table (3) Monitoring environmental changes in the study area 72|84

Statistical analysis of the programErdas Imagine9.3 ArcMap GIS10.3						
Type of change	Area in km2	%	Standard Deviation	Mean	Maximum	Minimum
Decreased	26974	86.26	13426	13427	26853	1
Increased	3840	12.28	2.593	0.033	522	0
Unchanged	458	1.46	0.338	0.013	22	0
Total	31272	100	13428.931	13427.046	27397	1

Source: The researcher as an example to illustrate the integration between remote sensing data, geographic information systems, and artificial intelligence techniques. (GeoAI)

It is clear from the table (3), and Figure (24, 25) The region is exposed to negative environmental changes due to loss and decrease, as the area of negative environmental changes due to loss and decrease is about 26974 km2, at a rate of 86.26% of the total area of South Sinai Governorate, while the area of areas subject to positive changes is estimated to increase by about 3840 km2, at a rate of about 12.28% Of the total area of the region. Areas that were not exposed to environmental changes were also recorded as: 458 km2, at a rate of about 1.46% of the total area of South Sinai, which amounts to about 31272 km2, which constitutes about 3% from the area of Egypt.

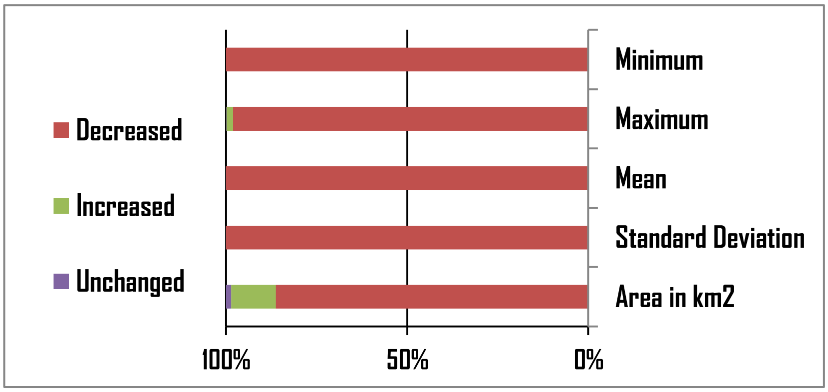


Figure (25): Statistical characteristics for monitoring the development of geomorphological changes in the southern Sinai Peninsula.

And it becomes clear using program Claude.ai, And Chat GPT4 Most areas of the southern Sinai Peninsula are exposed to negative changes due to loss and decrease, including the areas of St. Catherine, Qism Deb, Sharm El-Sheikh Qism, Abu Zneima Qism, Ras Al-Aqada, and Abordis; Which indicates the dominance of flood sculpting processes due to torrential floods, and the same applies to marine processes that...It is modified In the form of the beaches of the study area on the two coasts of the Gulf of Aqaba to the east, And Suez west.

The areas that have not been exposed to environmental changes are mainly concentrated in the south western part, near the Gulf of Suez, where they appear only in small, scattered areas in the Muis section, the Tor section, and the Taba section, far northeast of the research area. Which indicates that these areas have maintained their environmental conditions?

The positive changes are clearly concentrated in the margins and outskirts of the study area, and at the ends of the wadis (wadis exits), which indicates an increase in flood sedimentation processes due to the sediments dumped by torrents on the surfaces of flood fans such as the Dahab fan, Kidd fan on the eastern coast of the study area, and the Sidr fan. The Qaa Plain area is in the far southwest of the region. This indicates that the area Witness Severe changes since 1972, 1984, and until now.

The analysis of geomorphological developments and changes in the South Sinai region, as highlighted by the study, emphasizes the ongoing and significant transformations in the area. The spatial evolution of geomorphological features between 1972 and 1984 reveals that the valley areas fluctuated between 23% and 30% of the total study area, respectively. This indicates an increase of approximately 2,200 km² in valley areas, attributed to intensified fluvial erosion processes and the expansion of drainage networks.

Historical flood records in South Sinai indicate that the region experienced minor floods in 1972, predominantly affecting mountainous areas and subsequently urban zones located in flood paths, such as Dahab. In 1976, heavy rains resulted in moderate floods, impacting low-lying areas and mountain passes. During the 1980s, particularly in 1982, severe floods were recorded in the northern part of South Sinai, specifically in the study area. By 1984, at the end of the study period, South Sinai experienced extremely severe and destructive floods, leading to significant material and human losses, particularly in mountainous regions and low-lying urban areas.

The increased risks associated with these devastating floods are linked to the morphometric characteristics of the dry valley channels in the region. These floods, caused by heavy rainfall concentrated over short periods, led to rapid and intense flooding. The study area’s susceptibility to floods is due to climatic changes and unexpected increases in rainfall, coupled with the region's mountainous terrain and steep slopes, which facilitate rapid water accumulation and flow towards low-lying areas. This highlights the crucial role of floods in altering the topography and transporting substantial amounts of sediments, thereby playing a significant role in the geomorphological evolution of South Sinai (SpringerLink, n.d.).

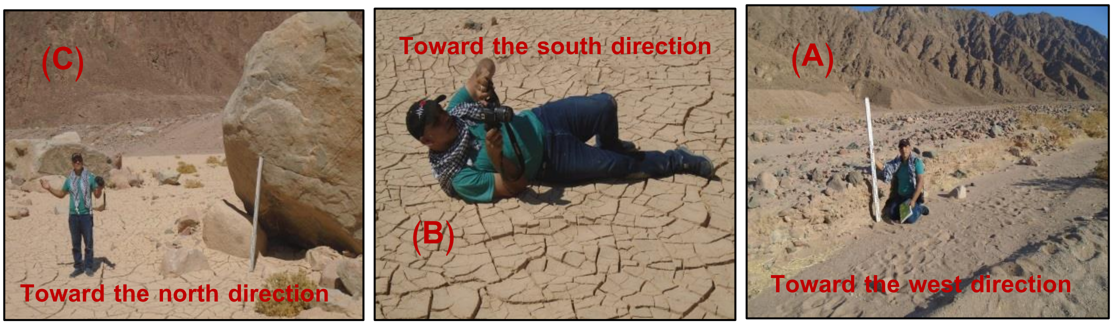


Figure (26): **Image** (**A**): Shows a gravel bank along the main flood channel in the central sector of the Wadi Al-Nasb fan, extending for 125 meters.

The photograph is taken facing west. **Image** (**B**): Indicates mud cracks, one of the flood features in the study area within the Wadi Zaghr basin, facing southwest. **Image** (**C**): Also indicates mud cracks and the extent of sediments resulting from the floods in the study area within the Wadi Zaghr basin, facing northwest. This highlights the intensity of the floods experienced in the region.

Geomorphological Developments and Changes in South Sinai (1972-1984):

As indicated by the analysis in Figures 22 and 24, sand dune areas witnessed a significant decrease in their extent and distribution within South Sinai between 1972 and 1984, forming approximately 30% to 15% of the total area, respectively. This reduction in sand dune areas might be attributed to changes in climatic patterns, such as decreased rainfall, which reduces sand deposition. Additionally, higher temperatures can increase moisture evaporation and reduce soil moisture, making sand more prone to wind erosion. Field studies in Dahab, South Sinai, observed attempts to remove vegetation cover, leading to soil degradation and sand loss, significantly contributing to environmental degradation. Human interventions and activities in the area also play a role in these changes.

Regarding the changes in highland areas, the analysis revealed that highlands constituted about 12% to 20% of the total area, with an increase of approximately 2,500 km². This might indicate changes in land classification or the increased exposure of bedrock due to erosion (Figures 5, 6, 7). The analysis also showed that valley deposits in South Sinai decreased during the study period, constituting about 24% to 16% of the area, with a reduction of approximately 2,500 km². This suggests increased sediment transport or transformation into other landforms.

Floodplain deposits in the area increased by approximately 4% to 10%, with an estimated increase of 1,875 km². This might reflect changes in sedimentation patterns or the reclassification of certain areas. Sebkha deposits covered a large area, particularly in 1984, indicating significant environmental changes such as increased salt deposition. The classification map analysis also suggests changes in land classification or the transformation of certain areas into other landforms, such as human exploitation of sebkha areas.

The general analysis of geomorphological development and changes in South Sinai reveals the following:

1. **Intensification of valley networks**: Indicates increased fluvial erosion and possible changes in rainfall patterns.
2. **Decline in sand dune areas**: Reflects changes in climatic conditions or human intervention.
3. **Increase in highland areas**: Indicates accelerated erosion processes or changes in land classification.
4. **Changes in valley and floodplain deposits**: Reflect transformations in sedimentation and transport dynamics.

5. **Disappearance of sebkha deposits in many areas:** Suggests changes in local environmental conditions or reclassification of these areas, with a general increase by 1984 indicating increased salt deposition.

These combined changes suggest a significant transformation in the geomorphological landscape of South Sinai between 1972 and 1984. These changes could result from natural factors such as climatic changes or human factors such as economic development and changes in land use in the region (Figure 23).

Conclusion:

The researcher addressed several main points in this research, which are the following points:

1- Artificial neural networks are inspired by the human brain, and consist of multiple layers of interconnected computational units.

2-Artificial neural networks are used in image classification, identifying their salient features, and extracting data from them, as they rely on simulating the functioning of biological neural cells to process data and extract patterns and relationships through machine learning processes. They are also employed in modeling phenomena, spatial prediction, and detecting changes in geographical studies, due to their distinctive ability to handle non-linear and complex data, making them a powerful tool in multiple fields including image processing, computer vision, and spatial geographical prediction.

3- Convolutional neural networks and recurrent neural networks are the most important types of networks used in analyzing aerial photos and satellite imagery.

4- The programming language Python and the open-source libraries Keras and TensorFlow are considered the primary tools widely employed in the field of designing and training artificial neural network models. Python provides an ideal programming environment for data manipulation and scientific computing, where Keras offers a high-level application programming interface (API) that facilitates the process of building and developing neural network systems with ease. On the other hand, TensorFlow, a low-level framework, provides a robust infrastructure for numerical computation distribution and operation acceleration on central processing units (CPUs) and graphics processing units (GPUs). Thanks to these libraries, researchers and developers can define suitable neural network architectures, select optimal activation and training functions, and apply evaluation and optimization methods to the trained models using various machine learning processes. This consequently leads to achieving optimal performance and productivity for artificial neural network models.

5- His depends to choose the type of neural network appropriate depends on the nature of the problem and the characteristics of the available data.

It is clear from this research the important role played by artificial neural networks in analyzing aerial photos and satellite imagery in geographical studies, especially in the field of physical geography. The applications of neural networks have been Salient as follows:

- **Classification of aerial photos and satellite imagery:** where can Use Artificial neural networks in classifying rock types, geological structures, vegetation types, and other geographical features.

- **Modeling geographical phenomena:** where can Use Artificial neural networks for modeling geographical phenomena Complex, such as flood distribution and spread Drought, and corrosion the soil.

- **Spatial prediction** artificial neural networks make it possible to predict future geographic events or models, such as urbanization, climate change, and natural disasters.

- **Change Detection** artificial neural networks can be used to detect changes in geographic features over time, such as the retreat and expansion of the ice cover. Al-Hadary, and change Uses Lands.

- The research concluded that artificial neural networks have become a powerful and effective tool in geographical studies, as they help in…Extract Information and analysis of complex geographical data, and forecasting future changes, which contributes to improving our understanding of the environment and better planning for the future.

Results:

The study in this research concluded with many results, the most important of which are the following:

1-Artificial neural networks can be effectively utilized to analyze aerial images and satellite imagery in the southern Sinai Peninsula.

2-Convolutional artificial neural networks were designed to predict geomorphological changes in the area and showed good results on test data.

3-Artificial neural networks can be used as a powerful tool to support decision-making in the fields of urban planning, natural resource management, and environmental protection.

4-Artificial neural networks can be used to enhance the accuracy of existing geological maps and to predict the evolution of geological structures over time.

5-Neural networks can be used to analyze climate data and predict future climate changes and their impacts on the environment and society.

6-Neural networks can be utilized to enhance water resource management and predict risks of floods and droughts.

7-Neural networks can be employed to enhance urban planning processes and accurately identify areas susceptible to natural disasters.

Recommendations:

The study recommends the following:

1-Procedure more studies to evaluate the performance of artificial neural networks in other geographic applications.

2-Development more complex neural network models to improve prediction accuracy.

3-Necessity of provision More high-quality geographic data to train neural networks.

We hope that this research will contribute to the development of...Use Artificial neural networks in geographic studies, improving our understanding of the environment and planning better for the future.

4-As the current study recommends developing geospatial applications based on artificial neural networks to enable decision makers to...Take Informed decisions.

5-There is a need to strengthen collaboration between geographers and data scientists to develop applications of neural networks in geographical studies.

6- To allocate more resources for training geographers in the use of artificial neural networks.

7-More Awareness of the importance of artificial neural networks in geographical studies. Its role in improving our understanding of the environment and planning for the future.

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