Revolutionizing Geospatial Analysis Through the Integration of GIS, GeoAI, and Geospatial Programming: a Comprehensive Review

Mohamed Shamroukh and Mohamed Alkhuzamy Aziz

June 28, 2023

Revolutionizing Geospatial Analysis through the Integration of GIS, GeoAI, and Geospatial Programming A Comprehensive Review

* Mohamed Shamroukh Mohamed, ** Mohamed Alkhuzamy Aziz
(*) Faculty of Arts, South Valley University, Egypt (**) Faculty of Arts, Fayoum University, Egypt
Correspondent: Mohamed Shamroukh Mohamed, South Valley University, Egypt,
E-mail: mohamedshamroukh@art.svu.edu.eg, ORCID ID: https://orcid.org/0000-0002-1005-2600

Abstract:

Smart spatial analysis is one of the most recent trends in geographic information systems and science, which focuses mainly on processing the continuous flow of a huge amount of spatial data that makes up Big Geodata. Through the processing and analysis of this data, information can be extracted quickly enough to make use of it in decision-making processes.

Smart Maps represent geographical information platforms that contribute to decision-making processes through the data, statistics, and information they provide about geographical features and phenomena. Networks are also highly required to determine the most appropriate paths to reach a site, and other applications that allow community participation and provide information on monuments and archaeological areas, and other applications that provide government services.

Geo-Artificial intelligence applications provide tools and methods that enhance the capabilities of GIS in the processing and analysis of Big Geodata, through smart models that are trained on a set of data to identify geographical phenomena and then work on extracting them from space visuals and images. There are several fields and applications including weather, in addition to many applications such as prediction, in which models are trained on the available data and then they derive the missing data or predict changes that may occur by studying the time changes in them.

Programming contributes to enhancing the capabilities of GIS through developing existing analytical tools or through building new tools and functions that enhance the capabilities of GIS software, as well as the possibility of automation of tasks to speed up their implementation and save time and effort.

Algorithms are a starting point for complex multi-criteria spatial analyzes because they provide a constructive format that allows the implementation of analytical operations according to their sequence and then to compare the results with the specified conditions after achieving the criteria used to reach the final map that provides alternatives for the decision-maker, and the algorithm can be applied in sharing and implementing on big geographic data.

Keywords:

Smart Spatial Analysis, Smart GIS, Smart maps, Geo-Artificial intelligence, GIS programming, Algorithm spatial analysis.

Introduction:

Geographical information systems represent the latest applied computer fields that contribute to supporting contemporary geographical studies through providing automated methods for analyzing spatial data after linking it to attributed data which gives various results to enhance the extraction and support of contemporary applied geographical thought (Aziz, 1998, p. 3).

Spatial data modeling methods, which represent the backbone of Analytical GIS, contribute to the optimal use of data, especially those that vary in terms of type, quantity, and source, and which are difficult to deal with, without achieving information integration, and for analyzing the spatial variables of that information, for extracting the characteristics of change, for diagnosing the spatial and non-spatial factors that led directly or indirectly to the change, and for developing solutions to confront the negatives of change (Aziz, 2007, pp. 11–12).

Geospatial data analysis is a key component of decision-making and planning for numerous applications. Geographic Information Systems (GIS), such as ArcGIS ®, QGIS®, provide rich analysis and mapping platforms. Modern technology enables us to collect and store massive amounts of geospatial data. The data formats vary widely, and analysis requires numerous iterations. These characteristics make computer programming essential for exploring this data. Python is an ideal programming language for automating geospatial data analysis.(Tateosian, 2015, p. 1).

Spatial analyzes show the power of GIS in providing solutions to surrounding spatial problems and in providing alternatives to support decision-making. Such alternatives to support decision-making are maintained and performed through the analysis of satellite images, through the discovery of Spatio-temporal changes in the land cover, and through programming and algorithms that enhance the capabilities of GIS in the implementation of spatial analyzes, through the application of smart modeling and smart spatial analyzes based on scripts, algorithms, and through artificial geographical intelligence models.

Smart Maps:

Smart Maps are the current generation of maps. Smart Maps are important tools that contribute to accelerating progress in various development processes and that help to provide the information needed by decision-makers, as well as activating the role of community participation. As we are in the era of big data, smart maps represent the optimum way to make use of these huge amounts of data. Smart cities provide geographic information services and various data that can be accessed by the public through searching for specific topics such as geographical locations of places, buildings, natural environment, and public facilities. (Rotună, Cîrnu, & Gheorghiță, 2017, p. 313). There is a growing need for web-based GIS (smart maps) to publish quickly and easily, share, display and process geographic information, which helps support decision-making for many natural resource-based applications(Singh, Chutia, & Sudhakar, 2012, p. 261). Smart Maps is an important tool for Smart Cities because of its extended capabilities and developed advantages.

1- Features of smart maps

There are many characteristics of smart maps which vary from one map to another, and the following is a presentation of the most prominent of these characteristics.

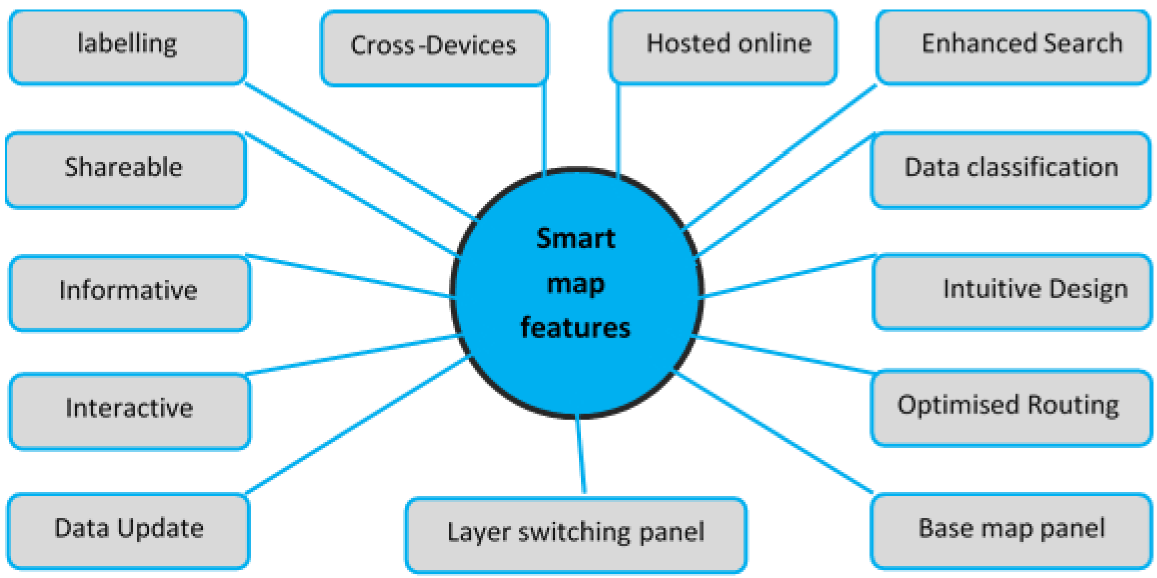


Figure (1): The characteristics of smart maps

Figure (1) shows the characteristics of smart maps. These characteristics could be illuminated through the following points:

Enhanced Search: It means searching the contents of the map or geodatabase through SQL[1] to extract information from the map to view it.

Data Classification: The data is classified within the database as well as in the displayed map. **Intuitive Design**: The design of the smart map is simple so that the public can understand its contents.

Optimized Routing: The map is enriched with data and information about the road networks and the most prominent landmarks, which is reflected in determining the optimal path, as well as in checking and improving the network.

Layer switching panel window: A window for switching between layers of the map.

Base map panel switching window: a window for switching between base maps.

Data Update: The ability to update the contents of the map, as the update is done through the Updates Admin manually or automatically through an algorithm that collects information from online or local resources and updates the geodatabase.

[1] SQL is an abbreviation for Structured Query Language, which is the language used to perform operations on databases, including adding, updating, or deleting data from the database, or to modify the structure of the database itself, in addition to its use in building databases.

Interactive: Interact with the user by querying or clicking on the map or showing information. **Rich in information**: It provides all the information that the user needs concerning the feature represented on it.
Shareable: The user can share it on the Internet.
Labeling: The names of the features are written on the map so that the user can easily identify them.
Cross-Devices: The smart map works on computers, tablets, and various systems and devices.
Hosted online: The map is uploaded to a server and then activated so it can be available online.

Smart Maps Applications:
Figure (2) shows the most prominent smart map applications. The data are displayed in 2D or 3D formats. They are divided into three main categories according to the type and nature of the application.

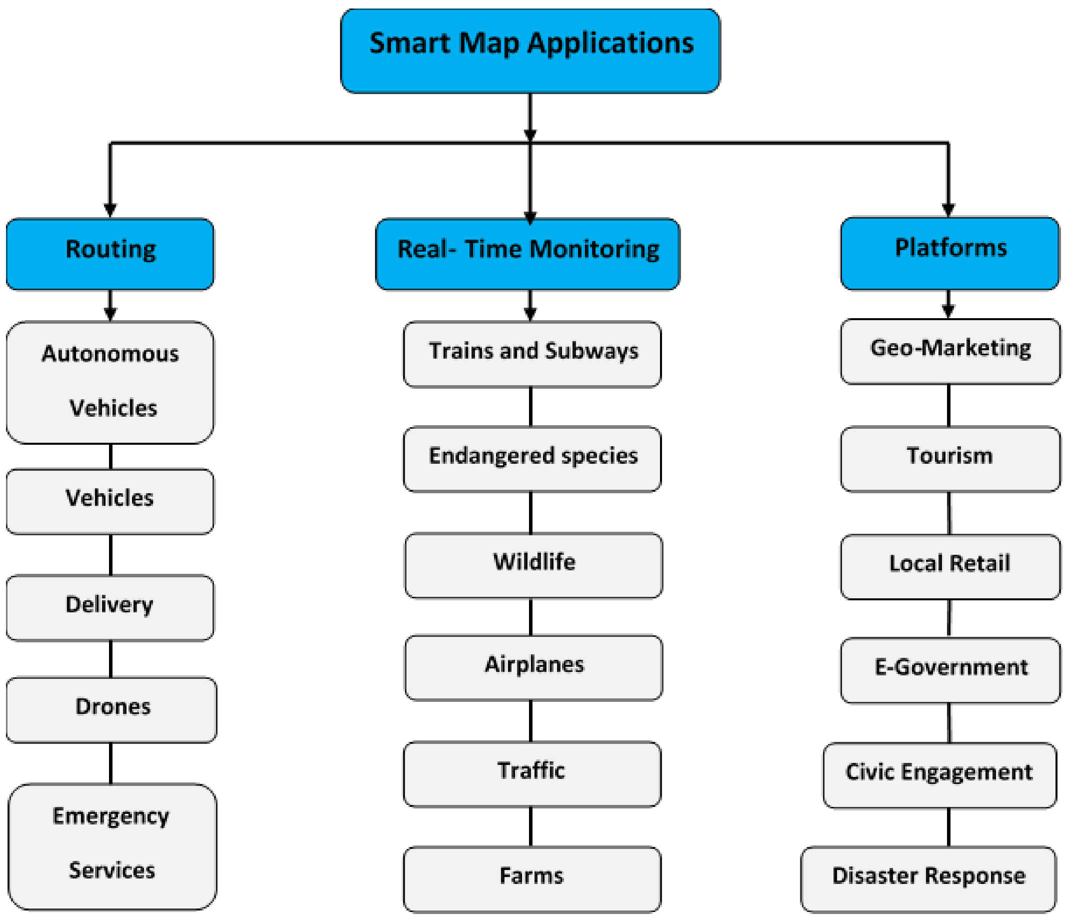


Figure (2): Types of Smart Map Applications

a- Platforms:

It includes applications that are associated with collecting data from the user and providing him/her with information interactively through search or request forms that have been responded to by the system, including Disaster Response applications that collect data from users and direct AID to affected areas, as well as identifying danger areas and directing residents to safe areas, and Civic Engagement platforms that work to spread community awareness and urge the local community to participate in the decision-making process. This is in addition to using the map as a gateway to receive suggestions or report problems, as well as using maps to the E-Government that works to provide public services through the platform. Moreover, Local Retail platforms help residents locate the nearest stores, in addition to Geo-Marketing platforms that use the geographic data of the population to direct services or commodity towards the target group. Tourism platforms are one of the most prominent applications of smart maps to provide information on tourist areas, their locations, and access methods. It encourages tourism, as well as its distinctive feature of displaying the most important tourist attractions and their historical value.

b- Real-Time Monitoring Applications:

These are applications that collect data in real-time to make decisions about it, which requires speed and accuracy. Such data is represented by the applications of monitoring the movement of trains, subways, and planes, which in turn, provide real-time broadcasting of their locations, contributing to the management of crises significantly or preventing their occurrence. Such applications also include applications of real-time monitoring of traffic density and finding solutions to the problems of congestion and choking roads by finding alternatives or paths that reduce this crowding. Additionally, such applications include real-time monitoring of farms through sensors that determine the health status of plants and satellite images through which farms are managed automatically, monitoring wildlife, especially endangered species, where their movements are monitored, and the dangers that threaten them and how to protect them.

c- Routing applications:

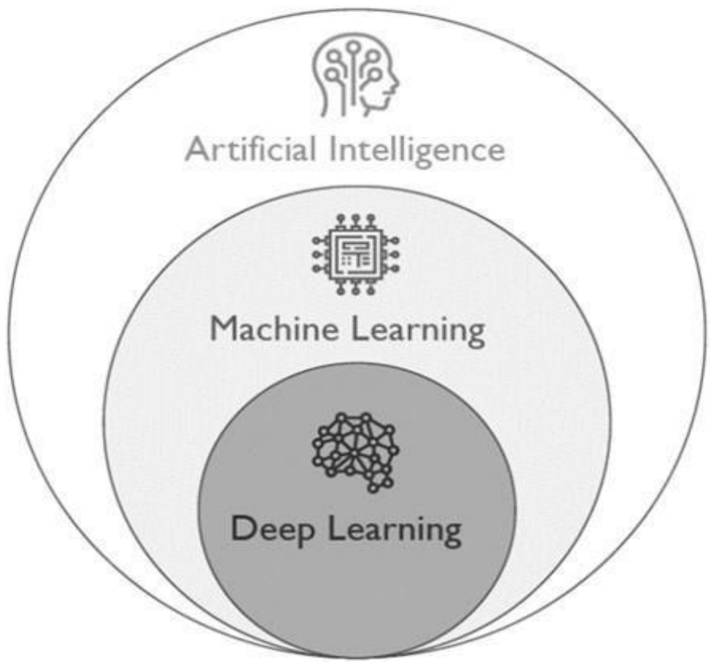
The applications that use road networks to deliver a service or access to a specific location, the most prominent of these applications are Autonomous Vehicles, which work primarily by conducting a laser scanning of the road in addition to using maps to determine their destination. Vehicles and delivery services are similar in the routing processor Navigation on the road network, in addition to the Emergency Services that use maps to determine the shortest and most appropriate paths such as ambulances. Drones could represent a different and new direction in smart map applications where the paths taken in the field survey are determined through the map, controlling its height, as well as instantaneous monitoring and recording of its movements.

Geo-Artificial Intelligence

Geospatial artificial intelligence (GeoAI) is an innovating scientific discipline that combines innovations in spatial science, artificial intelligence methods in machine learning (e.g., deep learning), data mining, and high-performance computing to extract knowledge from spatial big data. (Vopham, Hart, Laden, & Chiang, 2018, p. 1)

1- Artificial Intelligence (AI):

Artificial Intelligence (AI) can be defined as a branch of computer science concerned with automating intelligent behavior. This definition emphasizes that artificial intelligence is part of computer science, and as such it must be based on the theoretical and applied principles of this science. These principles include data structures used to represent the knowledge and algorithms needed to apply this knowledge in addition to the programming languages and techniques used in its implementation (Luger, 2005, p. 1). In other words, Artificial Intelligence could be described as the study and design of machines or computational methods that can perform tasks that usually require human intelligence to perform them (Hu et al., 2019, p. 1).



Source : (Zhao, Zhang, Xu, & Liu, 2020, p. 327)

Figure (3): The relationship between artificial intelligence, machine learning, and deep learning

2- Machine Learning (ML):

Machine Learning (ML) is a subset of artificial intelligence that enables a machine/computer to learn without explicit programming by focusing on automated extraction of patterns from data sets. ML primarily uses statistical techniques to enable computer systems to learn from data inputs and perform Predictions. Thus, machine learning could overcome definitively encrypted and closed algorithms and support data-driven decision-making processes. It has been used in a range of computing-related tasks such as content classification, network discovery, factorial planning, and spatial analytics. Particularly, machine learning has been widely used in land cover classification, geostatistical modeling, and simulation as well as in the areas of urban planning, disaster management and climate change adaptation (Zhao et al., 2020, p. 328).

3- Deep Learning (DL):

Deep Learning (DL) is a special type of machine learning that uses complex neural networks. The term “deep” refers to many layers within a neural network. These multiple layers allow deep neural networks to perform tasks in a hierarchical manner, requiring a deep learning algorithm, which is usually high-performance computational support. Therefore, multi-core processors are used to speed up the progress of mapping and simplify hierarchical layers. Deep learning like other techniques in machine learning, relies on data analysis rather than task-oriented software, and "deep layers" facilitate the extraction of features, which is a major challenge in traditional machine learning. Accordingly, DL has achieved tremendous success in tasks related to image analysis, such as scene exploration and feature extraction, as well as both segmentation or Isolation and Classification (Zhao et al., 2020, p. 328).

4- Big Geodata:

Geodata is normally defined as data about the surface and near-surface of the Earth. More precisely, geodata is observations about what is present at some location. Since the number of possible locations is infinite, geodata is often observed or captured in the form of aggregated or summary observations about areas (e.g., states, forest stands), lines (e.g., rivers, highways), or volumes (e.g., oil reservoirs, buildings); or geodata may be sampled at selected locations.(Goodchild, 2017, p. 19), Big Data is a term of comparatively recent coinage and has been the focus of a remarkable outpouring of energy and innovation in the past decade. The most obvious meaning of the term relates to data volume, and to the very rapid expansion of data storage and processing capacity in recent years.(Goodchild, 2017, p. 19), The concept of Big Geodata is comparatively recent and deals with the well-defined and important subset of Big Data that is geodata. As the Landsat, volume is no stranger to geodata, and today ability to collect and acquire geodata vastly exceeds ability to store or process them.(Goodchild, 2017, p. 20). Thus, the need for Geo-Artificial Intelligence to process and analyze this Geodata is essential to make use of it, considering the exceeding growth of Geodata and the need for more information to assist in the process of decision making.

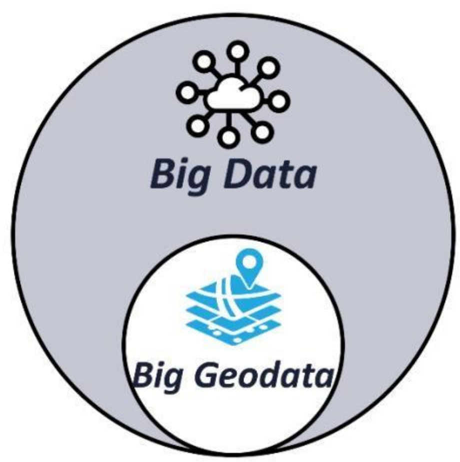


Figure (4): The relationship between Big Data and Big Geodata

5- Geo-Artificial Intelligence:

Nowadays, artificial intelligence (AI) brings tremendous new opportunities and challenges to geospatial research. Its fast development is powered by theoretical advancement, big data, computer hardware (e.g., the graphics processing unit, or GPU), and high-performance computing platforms that support the development, training, and deployment of AI models within a reasonable amount of time. Recent years have witnessed significant advances in geospatial artificial intelligence (GeoAI), which is the integration of geospatial studies and AI, especially machine learning and deep learning methods and the latest AI technologies in both academia and industry. GeoAI can be regarded as a study which is subject to develop intelligent computer programs to mimic the processes of human perception, spatial reasoning, and discovery about geographical phenomena and dynamics; to advance our knowledge; and to solve problems in human environmental systems and their interactions, with a focus on spatial contexts and roots in geography or geographic information science (GIScience). Thus, it would require the knowledge of AI theory, programming, and computation practices as well as geographic domain knowledge to be competent in GeoAI research. There have already been increasingly collaborative GeoAI studies for GIScience, remote sensing, physical environment, and human society. (Gao, 2021, p. 1).

The scientific field of geospatial artificial intelligence (GeoAI) was recently formed from combining innovations in spatial science with the rapid growth of methods in artificial intelligence (AI), particularly machine learning (e.g., deep learning), data mining, and high-performance computing to collect meaningful information from spatial big data. GeoAI is highly interdisciplinary, bridging many scientific fields including computer science, engineering, statistics, and spatial science. The innovation of GeoAI partly lies in its applications to address real-world problems. (Vopham et al., 2018, p. 1)

Geo-AI Applications:

It appears from Figure (5) that the current applications of Geo-Artificial Intelligence are numerous, and the most prominent of these applications are the following:

- **Prediction**: It is the use of known data values to derive unknown data values. The most prominent example is the Interpolation Methods like IDW and Kriging.
- **Geo-Enrichment**: It is the process of adding data to the map such as demographic data so that characteristics of a specific location within the map could be queried.
- **Clustering**: The creation of groups from Big Geodata according to a common characteristic.
- **Simulation**: It is the process of simulating reality for the purpose of studying it, such as simulating flash floods and floods.
- **Modeling:** It is a simplification of reality and a way of representing and linking spatial data to discover relationships and patterns.
- **Automation**: It is the transformation of operations that are done manually and that take enormous time and effort into tools that implement these operations automatically.

- **Classification**: It is the process of visually classifying groups according to common characteristics (pixel value) between them, represented by the processes of classifying land covers.
- **Object Detection**: It is the process of identifying features in satellite or aerial images.
- **Feature Extraction**: It is the process of extracting geographical features from satellite or aerial images.

The future applications of Geo-artificial intelligence represent an ambitious trend to enhance the capabilities of GIS software to speed up the processing of the huge and growing amount of data. The following are two examples of future applications:

- **Geo-AI Assistant**: It is an intelligent system that applies spatial analyzes and extracts information from data by automatically applying processing and analysis processes without the need for an experienced user to apply these analytics, such as Google Assistant. GeoAI assistant may be able to understand the needs of a GIS practitioner, automatically formalize and define the tasks, and identify candidate tools from a large GIS toolbox. (Hu et al., 2019, p. 8)
- **Improved Geo-Ai Models**: Improved model architectures (or the training process) so that the obtained GeoAI models can be transferred across different geographic areas (Hu et al., 2019, p. 9). They could be described as a smart geographic model that can be trained on data and can identify the characteristics and effects of different geographic areas, and thus can work without the need to create new models and train them on data from each geographic area separately. The flexibility of GeoAI workflows and algorithms can address properties of environmental exposures (as spatial processes) that are often ignored during modeling such as spatial nonstationary and anisotropy. (Vopham et al., 2018, p. 4)

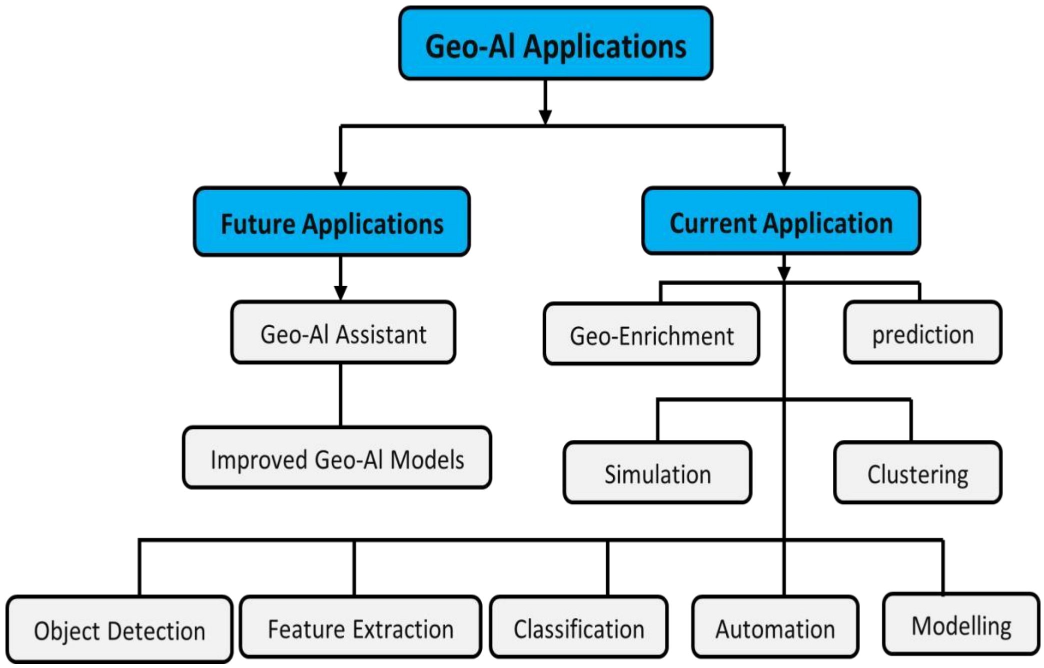


Figure (5): Applications of Geo-Artificial Intelligence

Programming in GIS

Spatial analyzes in a GIS environment require processing a huge amount of data that flows rapidly and increasingly. Usually, it is required to repeat these analyzes periodically, which makes it a difficult process consuming time and effort. Automation of work saves time and effort, and many programming languages are used in spatial analyzes and geographical data processing, the most prominent of which are Python and R.

1. Python

Python is defined as a high-level interpreted, object-oriented (OOP) programming language with variable semantics, and its combined high-level data structures with dynamic typing and dynamic linking make it very special for rapid application development, as well as its use as a scripting language to link components together (Python Software Foundation, 2021)

Python is used as a scripting language to do spatial analyzes and data processing, through a large group of Python libraries[2] that are developed by the Python community, and these libraries are available in an open-source and free such as shapely, Geopandas, mapnik, in addition to Arcpy, which is a python library developed by the Institute for Environmental Studies and Research (Esri) to enhance the capabilities of the ARC/GIS program, to perform data processing and spatial analyzes through Python using this library.

[2] A Python library consists of a set of modules, and modules are files written in Python that contain code instructions/commands designed to perform a specific task without having to write the code again and can be called and reused.

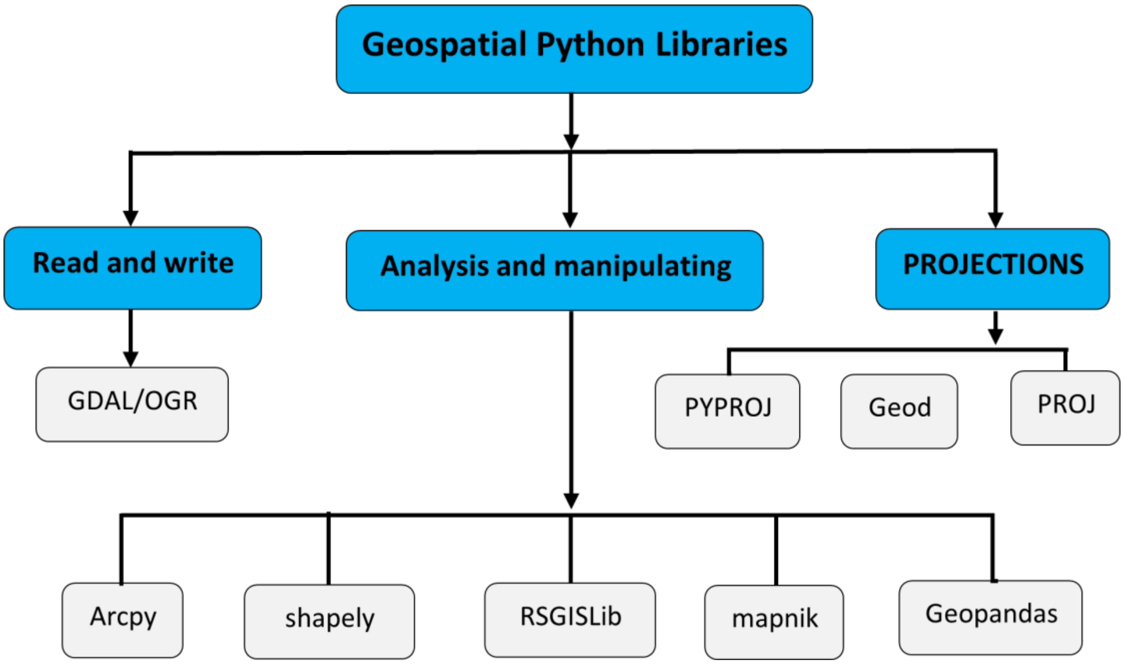


Figure (6): Python Spatial Libraries

As shown in Figure (6), the spatial libraries for Python are divided into three main categories, the first category deals with reading and modifying files, and the most prominent libraries are GDAL / OGR for vector and raster data, while the second category deals with coordinates and the most prominent libraries are PYPROJ, Geod, PROJ, the last category is concerned with data processing and spatial analyzes, including Arcpy, Shapely, RSGISLIB, mapnik, Geopandas.

```
# Import system
modules import arcpy
import os
#    Set    local    variables
in_features = "services.shp"
clip_features = "city.shp"
out_feature_class = "E:/output/cityservices.shp"
# Execute Clip
arcpy.Clip_analysis (in_features, clip_features, out_feature_class, "")
print ("Analysis completed")
```

Figure (7): A script for using the Arcpy. library

Figure (7) shows the use of the Python language and the Arcpy library to crop a data set for services within the city limits and then printing a message showing the completion of the analysis.

2. R Programming Language:

It is an integrated language and software environment for data processing, calculations, and graphical presentation. It has the ability to deal with data and facilitates its storage.(Vopham et al., 2018, p. 2)

The R language is used to display and analyze geographic data, and it enhances the capabilities of GIS software by adding new functions or accelerating spatial data processing through a set of R packages[3] that are constantly increasing. The number of software packages for the R language is about 17,865 various software packages (CRAN, 2021).

The R language includes many functions that are used to read, display, and analyze spatial data, and the focus here is on geographical data, which when querying a geographical location, the result of the query is represented in the form of additional information about this site. The software package "rgdal" is one of the most prominent software packages which is used to read and modify spatial data. Examples of software packages that deal with raster data include:

"raster", "terra", "stars", while the software package "sp" deals with Vector Data. Example of software packages for graphical data presentation include: "RcolorBrewer", "sp", "raster", "viridis", "classInt", "rcosmo". (Bivand, 2021)

```
longitude <- c(-116.7, -120.4, -116.7, -113.5, -115.5, -120.8, -119.5, -113.7, -113.7, -110.7)
latitude <- c(45.3, 42.6, 38.9, 42.1, 35.7, 38.9, 36.2, 39, 41.6, 36.9) lonlat <-
cbind(longitude, latitude) library(sp)
pts <- SpatialPoints(lonlat)
crdref <- CRS('+proj=longlat +datum=WGS84') pts
<- SpatialPoints(lonlat, proj4string=crdref)
```

Figure (8): A script for using the "sp" package

Figure (8) shows the use of R language and the "sp" software package in representing point spatial data through point coordinates.

Algorithms:

An algorithm[4] is an explicit, precise, unambiguous, mechanically executable sequence of elementary instructions, usually intended to accomplish a specific purpose.(Erickson, 2019, p. 1). Additionally, an algorithm is a procedure to accomplish a specific task. An

[3] R packages are a set of functions and code developed by the R community, to enhance the capabilities of the R language by adding new functions that can be used and shared among its users.

[4] Algorithm is a word derived from the Latin word "algorismus", which in turn is derived from the name Al-Khwarizmi, a Muslim mathematician, astronomer and geographer, the founder of algebra and his many contributions to geography.

algorithm is the idea behind any reasonable computer program. Interestingly, an algorithm must solve a general, well-specified problem. An algorithmic problem is specified by describing the complete set of instances; thus, it must work on and of its output after running on one of these instances(Richard Szeliski, 2020, p. 3). An algorithm could rather be defined as a set of rules that can be followed to solve a complex problem (Kennedy, 2000, p. 2).

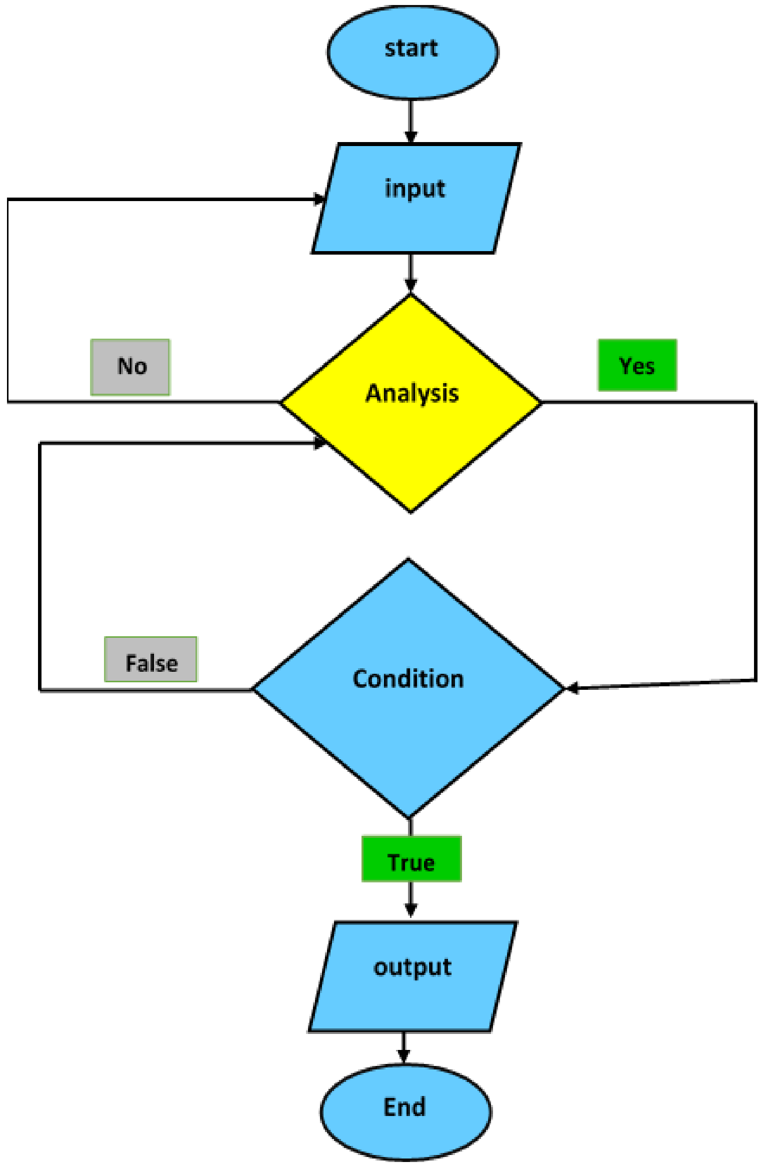


Figure (9): The structure of the algorithm

Algorithms and spatial analyzes:

Algorithms are used in spatial analyzes to develop and build a sequence of steps that must be followed to apply spatial analysis aimed at solving surrounding problems. Examples of algorithms used in spatial analyzes are Interpolation algorithms used in surface analyzes such as IDW, Kriging, Spline, in addition to many applications of spatial analytics that use Algorithms in solving spatial problems because of the abilities and distinctive features they provide that facilitate problem-solving as well as the repetition of their application.

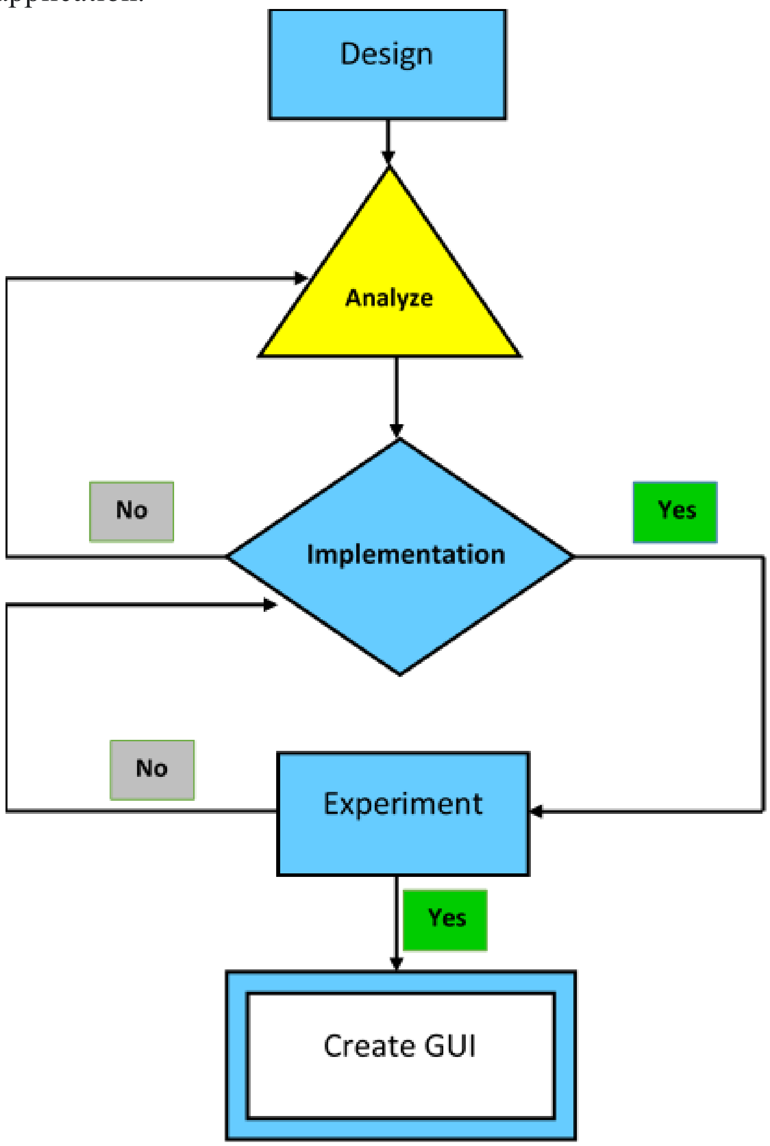


Figure (10): The stages of building a spatial analysis algorithm

Figure (10) shows that the stages of building the spatial analysis algorithm are six overlapping and sequential stages.

The following is a detailed discussion of these stages:

1. Design

The design stage means the initial sequence of the algorithm, the directions of movement of its components, and its interrelationship mechanism, starting from the inputs to the results. This sequence is represented in a schematic form of the algorithm.

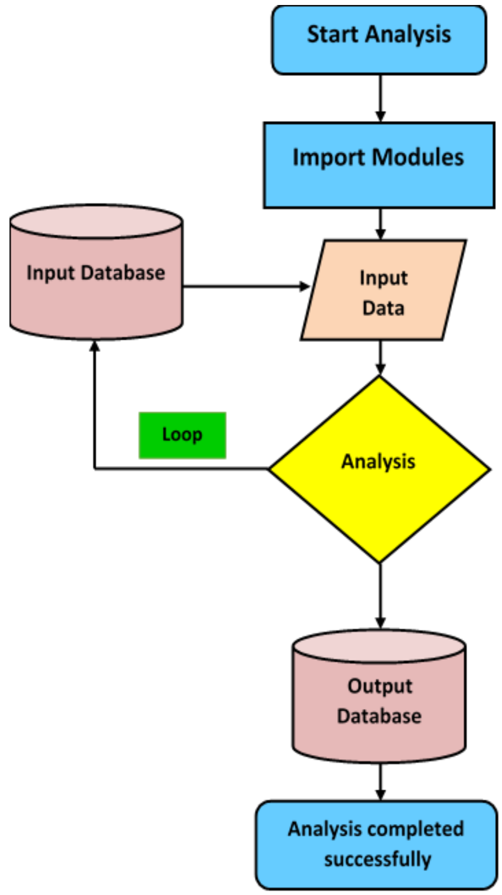


Figure (11): Design of the spatial analysis algorithm

2. Analyze

At this stage, the initial design of the algorithm is analyzed and the requirements for its implementation are determined. According to the previous design, this algorithm requires the following:

- A geographical database of the files on which the algorithm will be applied.
- A geographical database for the files resulting from the application of spatial analyses. • Integrated development environment (IDE)
- The programming language Python.
- Arcpy software library, OS module for dealing with the operating system, time module for calculating the time it takes for an algorithm to perform analyses.

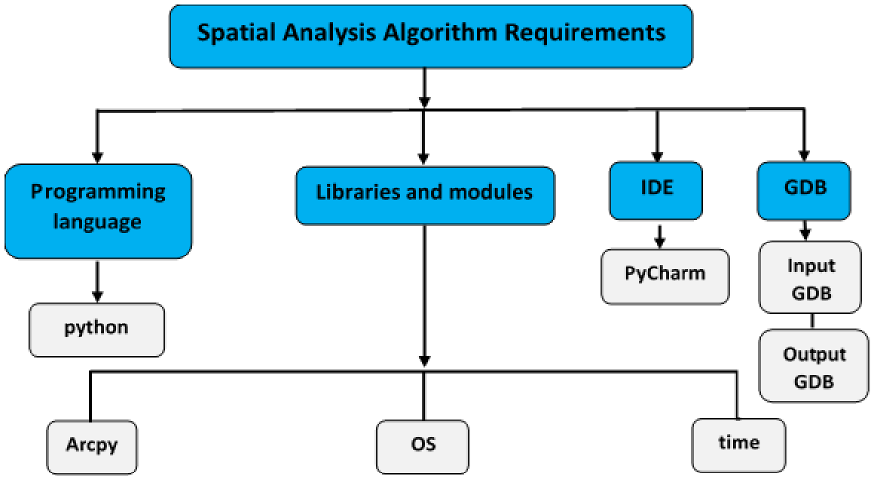


Figure (12): Requirements for building a spatial analysis algorithm

3. Implementation

This stage is based on the follwing steps: writing the code for the algorithm that was designed, using the python programming language and using the Arcpy programming library.

```
# created by: Mohamed shamroukh Supervised by Prof.Mohamed Alkhuzamy Aziz
# importing analysis module
import arcpy
import time
import os
start_time = time.time()
# Set the workspace for ListFeatureClasses
arcpy.env.workspace = r"D:\mawork\ALGORITHM\data"
arcpy.env.overwriteOutput = True
AnalysisOutput = r"D:\mawork\ALGORITHM\OUTPUT.gdb"
CityBorder = r"D:\mawork\border.shp"
# Use the ListFeatureClasses function to return a list of shapefiles.
FeatureClasses = arcpy.ListFeatureClasses()
# loop through the list of shape files
for ifc in FeatureClasses:
    BUFFER = os.path.join(AnalysisOutput, os.path.splitext(ifc)[0] + 'BUF')
    arcpy.Buffer_analysis(ifc, BUFFER, 500, "FULL", "ROUND", "ALL", "", "PLANAR")
    print "buffer analysis completed"
    CLIP = os.path.join(AnalysisOutput, os.path.splitext(ifc)[0] + 'CLP')
    arcpy.Clip_analysis(BUFFER, CityBorder, CLIP, "")
    print "CLIP analysis completed"
    arcpy.AddGeometryAttributes_management(CLIP, "AREA", "METERS", "SQUARE_KILOMETERS", "")
    print "area field added "
    print ifc + ' done'
# time elapsed
elapsed_time = time.time() - start_time
time.strftime("%H:%M:%S", time.gmtime(elapsed_time))
print "elapsed time: ", elapsed_time
print "Analysis completed successfully"
```

Source: Researcher's program based on the Python language and using the program PyCharm

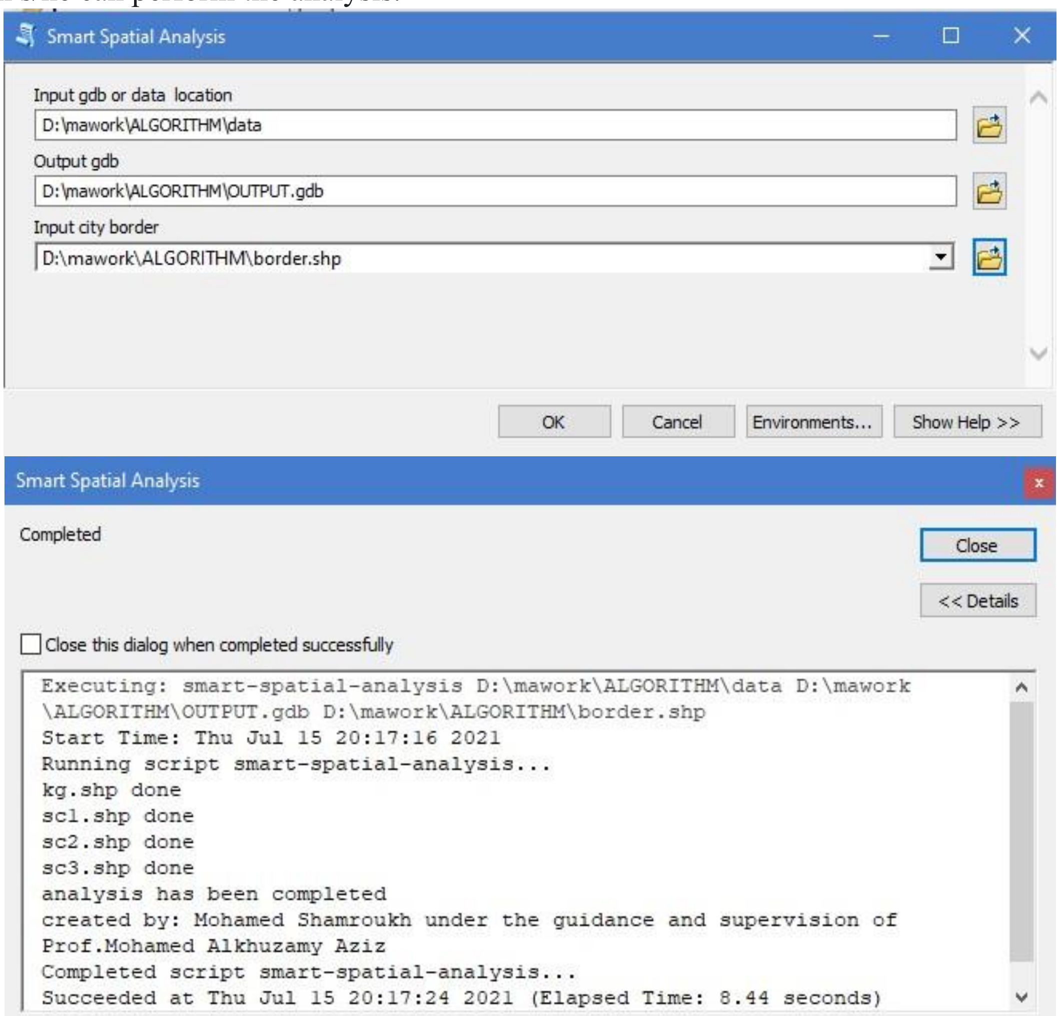
Figure (13): Script for Spatial Analysis Algorithm

4. Test Experiment

At this stage, the algorithm is tested, and the script is verified by experiment, and by running the algorithm script. The files within the geographical database or folder are discovered and indexed, and then spatial analyzes are to be applied to all the files. Then, the results are saved in the output database, and the process could take about 14 Seconds to apply the analytics to 4 files, i.e., 3.5 seconds for each file as a standalone script, and about 8 seconds inside an ARC/GIS environment, i.e., two seconds for each file.

5. Graphical User Interface (GUI)

The graphic interface[5] provides an executive window for the user so that s/he can deal with the algorithm and apply spatial analyzes without the need to learn programming languages, and through the interface, the user can specify the inputs and the outputs and then s/he can perform the analysis.



Source: researchers' work based on the Python language and using the program PyCharm, Arc/GIS

Figure (14): The graphic interface of the spatial analysis algorithm

[5] A graphical user interface (GUI) is a style of user interface through which one can interact with the contents of a screen or window via graphical forms.

Conclusion:

Smart spatial analysis is one of the recent trends in geographic information science and systems which focuses mainly on processing the continuous flow of a huge amount of spatial data through the processing and analysis of this data. Information can be extracted quickly enough to be used in the decision-making process.

Smart Maps are geographical information platforms that contribute to decision-making processes through the data, statistics, and information they provide about geographical features and phenomena. Such maps include Network analysis, which could be performed to determine the most appropriate paths to reach a site. Smarts Maps also include other applications that allow community participation and provide information on monuments and archaeological sites, as well as other applications that provide government services.

Geo-Artificial intelligence applications provide tools and methods that enhance the capabilities of GIS in spatial processing and analysis, through smart models that are trained on a set of data to identify geographical phenomena and then work on extracting them from satellite and aerial images, in addition to many applications such as Prediction, in which models are trained on the available data and then derive the missing data or predict changes that may occur by studying the changes over time.

Programming contributes to enhancing the capabilities of GIS by developing existing analytical tools or building new tools and functions that enhance the capabilities of GIS software in conducting spatial analyzes, as well as the possibility of automation of tasks to speed up their implementation and save time and effort while dealing with Big Geodata.

Algorithms are a starting point for complex multi-criteria spatial analyzes because they provide a constructive format that allows the analysis operations to be carried out according to their sequence and then the results could be compared with the specified conditions after achieving the criteria used to reach the final map that provides alternatives for the decision-maker. Moreover, the algorithm can be applied, shared, and implemented on the data especially the Big Geodata.

References:

- Aziz, M. A. (1998). *Geographical information systems basics and applications for geographers*. (Arabic Book), Egypt-Alexandria:Munshaat Elmaaref Publisher.
- Aziz, M. A. (2007). *Applied studies in geographic information systems*. (Arabic Book), Kuwait- Hawally: Dar Elelm Publisher.
- Bivand, M. R. (2021). CRAN Task View : Analysis of Spatial Data. Retrieved July 13, 2021, from cran.r-project.org website: https://cran.r-project.org/web/views/Spatial.html
- CRAN. (2021). Available Packages on CRAN. Retrieved July 13, 2021, from cran.rproject.org website: https://cran.r-

project.org/web/packages/#:~:text=Currently%2C the CRAN package repository features 17444 available packages

- Erickson, J. (2019). *Algorithms-UIUC*. Jeff Erickson.
- Gao, S. (2021). Geospatial Artificial Intelligence (GeoAI). *Oxford Bibliographies in Geography*, *4*(2005), 1–16. https://doi.org/10.1093/obo/9780199874002-0228
- Goodchild, M. F. (2017). Big Geodata. *Comprehensive Geographic Information Systems*, *3*, 19–25. https://doi.org/10.1016/B978-0-12-409548-9.09595-6
- Hu, Y., Li, W., Wright, D., Aydin, O., Wilson, D., Maher, O., & Raad, M. (2019). Artificial Intelligence Approaches. *Geographic Information Science & Technology Body of Knowledge*, *2019*(Q3), 12. https://doi.org/10.22224/gistbok/2019.3.4
- Kennedy, H. (2000). *The ESRI Press Dictionary of GIS Terminology*. RedlandsCalifornia: ESRI Press.
- Luger, G. F. (2005). Artificial Intelligence: Structures and Strategies for Complex Problem Solving. In *Zywienie Czlowieka I Metabolizm* (Vol. 5th). London,UK: Pearson Education, Inc.
- Python Software Foundation. (2021). What is Python? Retrieved June 9, 2021, from python.org website: https://www.python.org/doc/essays/blurb/
- Richard Szeliski. (2020). Texts in Computer Science. In *Algorithms and applications* (Third, Vol. 42). Cham, Switzerland: Springer Nature Switzerland.
- Rotună, C. I., Cîrnu, C. E., & Gheorghiță, A. (2017). Implementing smart city solutions: Smart city map and city drop. *Calitatea Vietii*, *28*(3), 313–327.
- Singh, P. S., Chutia, D., & Sudhakar, S. (2012). Development of a Web Based GIS Application for Spatial Natural Resources Information System Using Effective Open Source Software and Standards. *Journal of Geographic Information System*, *04*(03), 261– 266. https://doi.org/10.4236/jgis.2012.43031
- Tateosian, L. (2015). Python For ArcGIS. In *Python For ArcGIS*. London,UK: Springer International Publishing. https://doi.org/10.1007/978-3-319-18398-5
- Vopham, T., Hart, J. E., Laden, F., & Chiang, Y. Y. (2018). Emerging trends in geospatial artificial intelligence (geoAI): Potential applications for environmental epidemiology. *Environmental Health: A Global Access Science Source*, *17*(1), 1–6. https://doi.org/10.1186/s12940-018-0386-x
- Zhao, B., Zhang, S., Xu, C., & Liu, X. (2020). *Spoofing in Geography: Can We Trust Artificial Intelligence to Manage Geospatial Data?* Springer International Publishing. https://doi.org/10.1007/978-3-030-52734-1_19