International Journal of Management, IT & Engineering
(ISSN: 2249-0558)

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Title

INTEGRATION OF ARTIFICIAL NEURAL NETWORK AND GIS FOR ENVIRONMENT MANAGEMENT

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Abstract:

The purpose of a GIS is to provide both the individual and organization with increased knowledge and understanding of spatial data. Often GIS users overlook the 'decision making' capability these systems can provide, instead, focusing on the presentation. GIS information can become increasingly more valuable for decision making when coupled to artificial intelligence (AI). Artificial intelligence has evolved in recent years to the point that many applications can be run using desktop computing – thus within reach of many GIS professionals. When linked to GIS, artificial intelligence can be useful for evaluating, monitoring and decision-making. Neural networks, fuzzy logic, nanotechnology and evolutionary computation and others are directed toward decision-making functionality. In the case of artificial neural networks (ANN), computing methodologies are being used to simulate how the human brain processes spatial data problems. It is anticipated that many future spatial applications will incorporate elements of artificial intelligence. These networks have many potential applications in GIS including; land use, oceanography, forestry, consumer movement, transportation, bio-sphere studies, image analysis, environmental, entertainment, anti-terrorism, pattern analysis and health. In this paper we will briefly describe ANN, discuss the relationship of ANN to GIS and the benefits of their integration to environment management.

Keywords: Geographic Information System, Artificial Neural Network, Environment Management, Image Processing

1. Introduction:

The purpose of a GIS is to provide both the individual and organization with increased knowledge and understanding of spatial data. Often GIS users overlook the 'decision making' capability these systems can provide, instead, focusing on the presentation. GIS information can become increasingly more valuable for decision making when coupled to artificial intelligence (AI). Artificial intelligence has evolved in recent years to the point that many applications can be run using desktop computing – thus within reach of many GIS professionals. When linked to GIS, artificial intelligence can be useful for evaluating, monitoring and decision-making. Neural

networks, fuzzy logic, nano-technology and evolutionary computation and others are directed toward decision-making functionality. In the case of artificial neural networks (ANN), computing methodologies are being used to simulate how the human brain processes spatial data problems. It is anticipated that many future spatial applications will incorporate elements of artificial intelligence. These networks have many potential applications in GIS including; land use, oceanography, forestry, consumer movement, transportation, bio-sphere studies, image analysis, environmental, entertainment, anti-terrorism, pattern analysis and health. In fact, in almost every instance where GIS is being used, AI applications could potentially be developed for the purpose of enhancing decision-making capabilities. [5] In this paper we will briefly describe ANN and discuss the relationship of ANN to GIS and also analyze a framework for integration between GIS & ANN as one of powerful soft computing techniques.

2. Objective:

The objective of writing this research paper is

1. To discuss the relationship between GIS and Artificial Neural Network.
2. To analyze the framework for integration of GIS and ANN.
3. To study whether integration of GIS and ANN will help in environment management or not.

3. What is Geographic Information System (GIS)?

It is a special type of information systems which lacks an absolute definition. Really, there is no absolutely agreed upon definition for GIS and this lack of an accepted definition has introduced the problem of misunderstanding about what GIS is, what is its capabilities and its applications.

GIS defined as: *"A collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information"*. This means all possible tools which used in processing and analyzing of spatial data into useful information. This information is used in decision making process and in solving complex geographical problems. [7]

By joining both spatial and non-spatial data together we obtained much valuable data rather than view each one separately. In order to be joined correctly, each feature considered a record in database and has a unique ID which uniquely identifies each record. This ID is used to link this feature with its attribute data stored as a data record in a relational database and holds the same ID value of the feature.

GIS includes set of functions to support the acquisition, storage, querying, analysis and visualization of spatial data. These functions are called "A heart of GIS". They can be categorized into three main types: Input, storage and editing functions, Analysis functions and Output functions. [1]

4. What is Artificial Neural Network (ANN)?

Artificial Neural Network (ANN) is one of soft computing techniques which are a branch of AI. It is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain process information. A neural net consists of a large number of simple processing elements called *neurons*. Each neuron is connected to other neurons by means of direct communication links, each with an associated *weight*. The weights represent information being used by the net to solve a problem. Each neural has an internal state, called its *activation function*, which is a function of the inputs it has received. Neural nets can be applied to a wide verity of problems such as storing and recalling data or pattern, classifying patterns, performing general mappings from input patterns to output patterns, or finding solution to constrained optimization problems. Any neural network is characterized by

(1) Its pattern of connection between the neurons (*architecture*),

(2) Its *activation function* which based on data forms and

(3) Its method of determining the weights on connections (*training or learning*). [1]

The analyze framework will contain the strength of both GIS and ANN. So, it will be useful in assessment of decision maker in complex spatial problems. This integration will lead to extend GIS to develop modern GIS (traditional GIS with AI capabilities) and therefore can be used as a Spatial Decision Support System. [2]

5. Integration of GIS and ANN – A framework:

The architecture for integration between GIS and ANN is given in following figure 1. The following sections will be a brief description of its basic components and the mechanism of this architecture.

5.1 Components:

- ***Geo-databases:*** the basic component of the architecture is geo-database where both spatial and attribute data are stored and managed. In complex problem, several geo-databases may be available from different sources and in different formats.
- ***Spatial Data Warehouse:*** The spatial Data Warehouse is an extension of the conventional database base management system (DBMS). It is used specially to manage spatial data. It consist of some tools like Data Mining, Metadata and Data Mart
- ***GIS basic toolbox functions:*** this part is related to the functionalities of traditional GIS. As discussed that GIS has a set of functions and tools which support spatial analysis. These functions may be measurement functions, vector analysis functions, visualization functions or querying functions. [3]

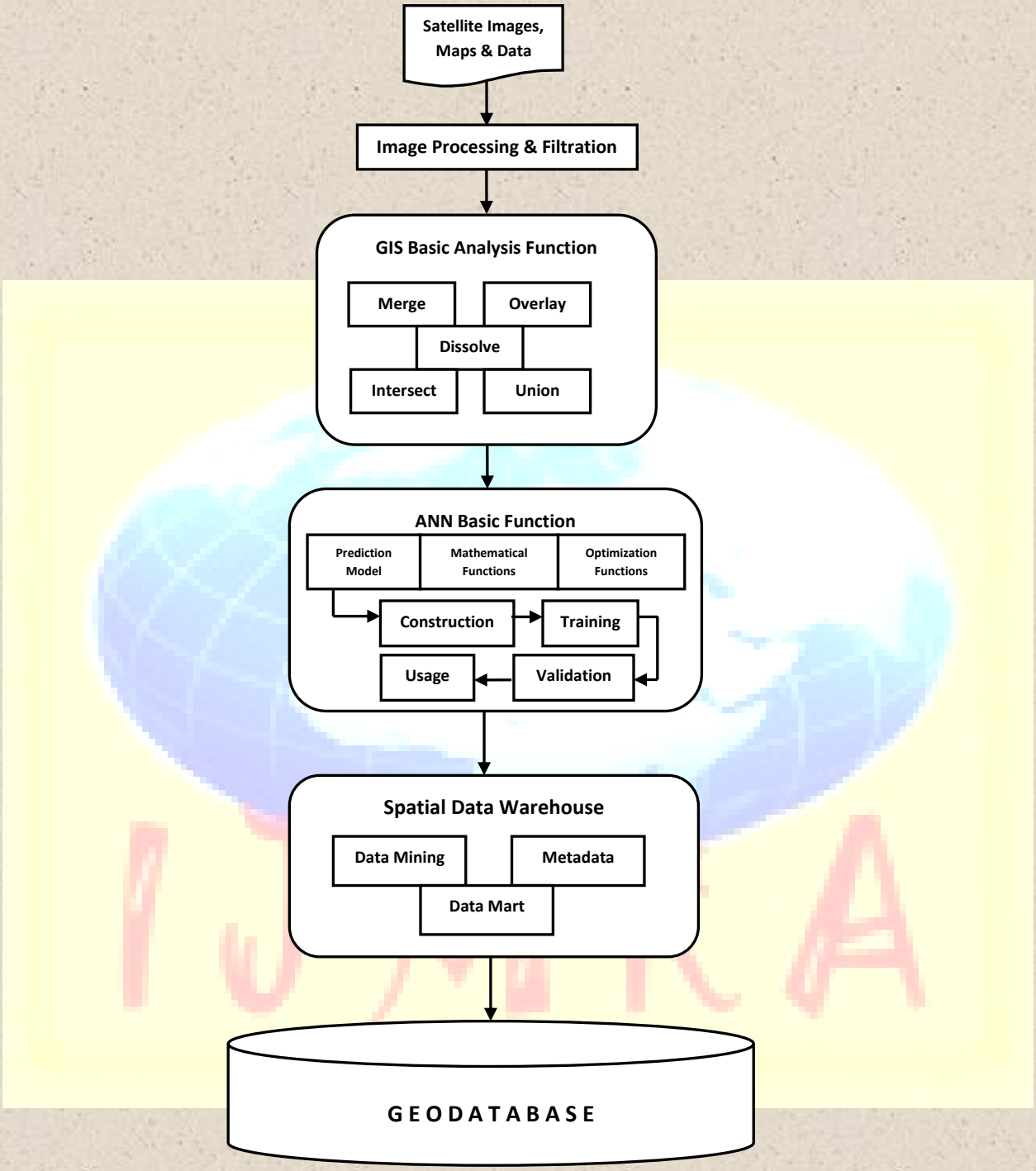

Figure 1. Integration of GIS and ANN

- ***ANN Basic Functions***

  • ***Modeling functions:*** either classification or prediction model is used a set of phases must be followed to get best results. 1st model construction functions are required to build the model in an appropriate form.2nd model training, testing and validation functions are required to measure the accuracy and the performance of the model.3rd using the resultant model should be provided through a systematic way.

  • ***Mathematical functions:*** a set of strong mathematical functions are required because of the nature of neural network and its learning method and algorithms. Statistical functions are also required to perform a lot of tasks in evaluating models.

  • ***Optimization functions:*** this part responsible for enhancement the performance of neural network to get best results. Such as normalization and transformation functions. These functions are used to increase the accuracy of the resultant model. [4]

- ***Image Processing and Filtration:*** includes processing of images and maps into the appropriate form or format. Various software was used for further processing of images.
- ***Satellite Images, Maps and Data:*** images taken with the help of satellite which is situated in an orbit. The associated data may be processed by the spatial Data warehouse.

5.2 Working:

The above architecture of integration between GIS and ANN work in following manner:

1. Images or maps are extracted with the help of satellite. The associated data may be then processed by the Data Warehouse.
2. Images are processed by the image processing software.
3. GIS functions are used to abstract and extract an important data which may be has an effect in classification or prediction task.
4. Data transformation may be done by two ways according to two types of spatial data:

   • *Raster data form:* the value of interested data for each pixel is transformed into one dimensional array as a record in an input dataset.

• *Vector data form:* the related data is extracted from attributed data tables and stored in separate DB to be an input to ANN.

5. Training dataset constructed and then inserted to ANN components which build an appropriate model (classification or prediction model) according to the desired task.
6. ANN after construction and training of the model, adjustment and optimization functions are then used to adapt the developed model.
7. Using the model will be the remaining task by inserting an input dataset and get an output results by the way of mining of data, metadata and data mart.
8. The final step storing the images, maps and its associated data in the form of geodatabase.

By this way, the integration will achieve a good result and the value of geographical data will become more valuable. This framework can be used to achieve a lot of tasks and extend the basic functionalities of traditional GIS to include modeling and simulation capabilities in aiming to support decision makers. [6]

6. Findings:

As we know that GIS is used for management spatial data while ANN is used to extend the functionalities of GIS by adding modelling and simulation capabilities. The integration forms will used to support decision makers in solving complex spatial problem. The choice of ANN from a large set of modelling techniques backs to easy adaptation of modelling parameters rather than any other method. Also, non-linear relationships between parameters in spatial data make ANN is preferable for environment management. Although, there are a lot of techniques for modelling and simulation but there isn't a single one which is optimal for all situations.

Hence integration of GIS and ANN is purely a new tool which helps environmental developer and planner to design their application more efficiently.

Conclusion:

In this paper ANN is chosen with GIS because of its powerful capabilities in modelling and simulation. While GIS is used in collecting, management and querying of spatial data, ANN is used to extend the functionalities of GIS to include modelling and simulation capabilities. The framework for this integration to be used later as a general framework in many fields of environment management. Here, ANN is used with GIS will be directed to support decision-making process. Other prediction models can be used with GIS as an alternative for ANN such as logical regression, mathematical model and decision trees. Thus the modern GIS will not only tell the user the result which based on specific search criteria but it will simulate to user what will happen in the future based on specific action or decision.

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