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Artificial Intelligence Geographic Information Systems-AI GIS

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ABSTRACT

The integration of artificial intelligence (AI) and geographic information systems (GIS) has opened up new possibilities and advancements in the field of geoscience. AI techniques, such as machine learning and deep learning, have shown great potential in solving various GIS challenges and improving the intelligence of GIS software. GeoAI, which combines AI with GIS operations, encompasses geospatial machine learning and geospatial deep learning. Geospatial machine learning in ArcGIS allows users to address tasks like geographical clustering, spatial classification, and spatial regression. Geospatial deep learning algorithms, on the other hand, enable advanced analysis of 3D data and images.

AI for GIS involves applying AI techniques to enhance the capabilities of GIS software. This includes AI attribute collection, AI survey and mapping, AI cartography, and AI interaction. By leveraging AI, GIS software can become more intelligent and efficient in handling data and performing various tasks. GIS for AI refers to the utilization of GIS capabilities in further processing and mining data obtained from AI recognition. By incorporating geographical visualization and spatial analytics, GIS can enhance AI findings and provide decision makers with more intuitive information expression. Examples of GIS for AI applications include traffic flow monitoring, city component management, real-time geo-fence alerts, and vehicle tracking. Prominent companies across industries are strategically investing in AI, particularly machine learning, and leveraging location data to gain competitive advantages. Location analytics is being used for discovering hidden trends, gaining critical insights, and making informed decisions. For instance, manufacturers use AI systems for supply chain logistics, inspections, predictive maintenance, and anomaly detection. Retailers benefit from machine learning and location intelligence for site selection, supply chain optimization, and personalized customer experiences. Government agencies utilize georeferenced drone

and satellite imagery for automation, modeling, prediction, and monitoring using machine learning algorithms.

While AI GIS has made significant progress, it currently falls under Narrow AI, which is designed to solve specific problems. General AI, capable of solving any AI-related problem, is a long-term goal for the development of AI in GIS. Nevertheless, advancements in AI technologies like speech recognition and language processing can empower GIS operations further.

Regarding data entry and geographic data problems, AI can offer potential solutions, including automated data entry and processing of geographic information. However, addressing specific challenges related to Arabic words in GIS systems would require specialized language processing capabilities tailored to the Arabic language. AI technologies can be trained on Arabic language data to improve their ability to handle Arabic words and linguistic nuances in geographic information systems.

Keywords— Artificial Intelligence – AI GIS – Attribute Data – Geographic Data- GeoAI

1 INTRODUCTION

Some points regarding the use of artificial intelligence (AI) to solve data entry and geographic data problems in geographic information systems (GIS), specifically related to Arabic words:

1. Data Entry Automation: AI can be used to automate data entry processes in GIS systems, including the entry of Arabic words. Natural Language Processing (NLP) techniques can be employed to analyze and understand Arabic text, extract relevant information, and populate GIS databases automatically. This can help streamline data entry tasks and reduce manual effort.

2. Language Processing: AI technologies, such as speech recognition and language processing, can be integrated into GIS systems to handle Arabic words effectively. This involves developing models and algorithms that can accurately recognize and interpret Arabic language inputs, enabling users to interact with GIS software using spoken or written Arabic.

3. Arabic Word Recognition: AI algorithms can be trained to recognize and understand Arabic words in geospatial data. This can involve the use of machine learning techniques, where algorithms are trained on large datasets of Arabic text to improve their accuracy in recognizing Arabic words and resolving geographic references.

4. Geocoding and Geographic Data Processing: Geocoding, the process of associating geographic coordinates with addresses or place names, can benefit from AI techniques in handling Arabic addresses and place names. AI models can be trained to identify and standardize Arabic addresses, resolve ambiguities, and accurately assign geographic coordinates.

5. Cross-Linguistic Challenges: Arabic, like any other language, presents specific linguistic challenges that need to be considered in AI-based GIS solutions. Arabic has unique grammatical structures, different forms of word morphology, and specific linguistic features. Addressing these

challenges requires training AI models on Arabic language corpora and considering language-specific rules and patterns.

6. Data Quality and Validation: AI can play a role in validating and enhancing the quality of geographic data, including Arabic words. AI algorithms can analyze and detect errors, inconsistencies, or missing information in Arabic data, enabling data cleaning and improving the overall accuracy and reliability of GIS datasets.

7. Localization and Multilingual Support: AI can be leveraged to provide multilingual support in GIS systems, including Arabic language support. Localization efforts can ensure that GIS software interfaces, labels, and user interactions are tailored to Arabic-speaking users, facilitating a more user-friendly and inclusive experience.

2 GIS and Artificial intelligence

The full potential of AI in GIS remains untapped. While there is a convergence of both disciplines in analytical aspects, most GIS applications that lend themselves to AI integration still rely on conventional approaches using standard tools from commercial GIS packages. Notably, artificial neural networks have shown promise in interpreting spatial resource information, particularly with widely-used backpropagation neural networks being favored by spatial planners. Numerous AI architectures and types have been developed, many of which are digitally based.

However, to enhance the practicality of AI for map-based applications, a more efficient methodology is needed to establish seamless communication between the GIS and a trained AI. The advancements in AI technology have transformed it into an applied mathematical technique, sharing some resemblances with the workings of the human brain. The integration of artificial neural networks with GIS opens up numerous possibilities for various applications, significantly improving decision-making processes.

The architecture of an AI involves multiple layers, each with adjustable weightings. During the training process, these weightings are iteratively adjusted until the network achieves the desired optimal firing or static state. Once trained, the AI can consistently and effectively perform various applications. By incorporating an AI into their toolkit, GIS professionals can elevate their spatial capabilities. The fusion of GIS and AI presents a promising opportunity to streamline the analysis of spatial information, reducing the time spent on data interpretation. This integration enables the interpretive results from a small area to be extrapolated to a larger, geographically similar region without the need for geographers to physically cover the entire area, thereby saving time and expenses.

AI can be viewed from two perspectives: as a scientific endeavor and as an engineering discipline, depending on the intended purpose of its application. While AI technology is commonly taught within the realm of computing, it also shares connections with various other fields, including psychology, philosophy, and linguistics. Within GIS, artificial intelligence methods can bring significant advantages over conventional techniques like statistical analysis, especially when dealing with nonlinear data patterns.

An intriguing aspect worth mentioning is that AI is frequently inconspicuous to its users – many people are unaware that they interact with AI regularly in their day-to-day lives. Despite this, AI plays a crucial role in enhancing various applications, including GIS, and offers substantial benefits over traditional approaches.

Developing decision-making models that allow decision-makers to incorporate constraints and imprecise concepts with geographic data, such as fuzzy logic, for handling large volumes of information can be costly. In real-world GIS classification problems, achieving 100% accuracy on all datasets is impractical. GIS users are concerned with two types of accuracy: first, the net's capability to learn from the data, which refers to its ability to effectively classify the training set, and second, its ability to generalize, indicating its performance on previously unseen data.

Accuracy is typically assessed by inputting a set of example data into the network and recording the number of correctly classified samples. Two immediate considerations arise from this process: first, how to present the classification accuracy to the user, and second, how to choose a suitable example set. Maintaining statistical independence between the training set and the example set is crucial when evaluating the network's generalization capabilities.

The current landscape in AI and GIS reveals a divide, with applications predominantly driven either by AI specialists or GIS experts, lacking joint and integrated projects. To bridge this gap, the convergence of AI and GIS should begin with GIS education. University GIS courses should incorporate lessons on artificial intelligence beyond fuzzy logic. Additionally, introducing geographical thinking and research methods in geography to AI courses would foster better mutual development between AI and GIS. This step would pave the way for accelerated research in geographic information science in diverse directions.

3 Implementation

For each data layer; Checks and validations are performed to measure the quality of each individual subitem by calculating the error percentage for each item and then calculating the percentage for the entire item, then calculating the percentage for each layer, and finally for the data layers for each dataset, by dividing the percentage by the number of quality item applied

Subsequently, the methodology that was applied to measure data quality,

- Data Completeness Measurements
- Logical consistency checks

3.1 Validate Geometry Omissions

This validated any missing features that exist in GIS data and does not in final produced data;

- Choosing random sample of data to check. This random sample was identified according to requirements scope
- Open source that shall be compared with data sample
- Compare between features of each layer in data sample and equivalent features in compared source
- Count number of drawn features of each layer within data sample (e.g. Number of drawn features in layer 1 inside data sample = X)
- Count number of actual features of each layer in the compared source within sample extent (e.g. Number of actual features in layer 1 inside sample extent = Y)
- Calculate feature omissions (Y - X = Z)
- Calculate omission percentage in each layer ((Z / Y)*100 = W)
- Calculate data completeness quality in each layer (100 - W = Quality %)
- Document the final validation results in the Quality Assessment Report

Sometimes, by reviewing buildings overlayed on high resolution satellite images, we found that some buildings were not drawn for some reasons. We can check this problem by reviewing the data or it can be done by using some tools in image processing and analysis. This can be done if we have the ability in AI GIS.

Fig. 1.Missed Buildings.

Sometimes, by reviewing roads overlayed on high resolution satellite images, we found that some roads were not drawn for some reasons. We can check this problem by reviewing the data or it can be done by using some tools in image processing and analysis. This can be done if we have the ability in AI GIS.

Fig. 2.Missed Roads.

3.2 Validate Attributes Omissions

This validated any missing attributes that exist in data source and did not in final produced data.

Choosing random sample of data to check. This random sample was identified according to requirements scope.

- Using the attribute table of each layer within data sample, Count number of cells which exist in data sample (No. of columns * No. of Rows = M)
- Count number of filled cells in each attribute table of a layer (e.g. Number of filled cells in the attribute table of layer 1 = X)
- Count number of empty cells -which should not- (e.g. Number of empty cells = M - X = Y)
- Calculate attribute omission percentage in each layer ((Y / M)*100 = Z)
- Calculate completeness percentage quality in each layer (100 - Z = Quality %)
- Document the final validation results in the Quality Assessment Report.

Roads are without names. Sometimes we need to check for the roads that have been named and select roads that have not been named. We can calculate the percentage of named features. Sometimes, we can find some roads already without names after field check. This can be done using attributes selection and field survey for check.

Also, Sometimes we need to check for the buildings that have been named and select buildings that have not been named. We can calculate the percentage of named features. Sometimes, we can find some buildings already without names after field check. This can be done using attributes selection and field survey for check.

Fig. 3.Building Name (392 out of 176563) = 0.2% very low.

4 Results and discussion

Checking all areas using some check points and calculating the percentage of all Geographic Information System data. If the percentage is lower than 90% for example it will be refused, or it should be checked again and correct errors from field survey. All these steps need to be simplified using AI GIS. In our example, the percentage is very low, 69%.

Fig. 4.Checking points (Red is Errors – Yellow is Correct).

We chose 75 known points to check the quality of GIS data.

No of Check points	Correct	Errors	% of Errors
75	52	23	31 %

Area is not Exist: In the following figure we can see some areas are not drawn roads and buildings.

Area is not Exist.

General Notes:

Roads without names	**Can be checked using attribute some tools**
Missed Buildings	Can be checked using Remote sensing tools
Missed Roads	Can be checked using Remote sensing tools
Topology errors	Can be checked using Topology tools
Streets with wrong names	Is it can be checked using AI ?
Typing same names with different format	Is it can be checked using AI ?
Duplicated names	Can be checked using attribute some tools
Discrepancy spelling	Is it can be checked using AI ?
Missed street names especially famous streets	Is it can be checked using AI ?
Spot height errors	Is it can be checked using AI ?
Roads intersection with Buildings	Can be checked using Topology tools
Area is not drawn.	Can be checked using Remote sensing tools

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