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GeoAI – The Future Was Here!

GIS Trends

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Abstract

Artificial Intelligence (AI) in the geospatial data sphere has been around for some time - albeit under different monikers, including "deep learning" and "machine learning". Both commercial and open source software have options for the current brand of AI, and these are discussed. Some machine learning training models are also openly available for use. Whether any of this will be relevent tomorrow is given cursory consideration.

Editorial

By now, you've likely heard a lot about AI. ChatGPT and its fellow morally ambiguous siblings have been popping up everywhere since their launch earlier this year (2023). But have you heard of GeoAI? It's the latest hot new trend that came into being many years ago! It wasn't called AI then – rather, it was referred to as machine learning- the more realistic, less sexy term. However, my pedantry is not at issue. Instead, let's discuss "AI"/"deep learning"/"machine learning" in GIS!

To start, AI is a type of computing meant to mimic human interactions with information to "learn", or, more realistically, analyze information. Depending on who you ask, AI, machine learning, and deep learning may all be synonymous, or may be subsets of each other (deep learning being a subset of machine learning, and machine learning a subset of AI). GeoAI uses artificial intelligence, or machine learning, to work with and analyze geospatial data. It allows for the automation of extraction, classification, and detection of information from visual and textual data,

such as raster maps, air photos, or written information (Esri, 2023a). Most often, this takes the form of computer vision – in other words, the image classification done by various systems. When you upload an image to social media, for example, you may have noticed it gets auto-classified with metadata (e.g. "Image may be a person with a dog"). This is computer vision at work.

The primary forms of computer vision used in GeoAI at the moment fall into four categories:

1) Image Classification – determining the image's main subject (e.g., a road or a dog).
2) Object Detection – determining that there are separate objects within an image and what they are (e.g. two trees, each with a square showing approximately their space in the image).
3) Semantic Segmentation - assigning a class to every pixel in the image so that every pixel that is a road gets labelled a road, or all the pixels belonging to the dog are part of the dog. This is determined not only for main object or objects of the image, but for every pixel that is a part of the image (e.g. the dog, the sky, the tree, and the ground, or the road, the cars, the fields, and the buildings). All pixels belong to something and are classified as that thing.
4) Instance Segmentation – this is something of a hybrid of Object detection and Semantic Segmentation. In this case, the objects are not only determined but the pixels that form the object or objects are defined and classified as such (e.g. each pixel making up dog A is classified as Dog A, each pixel making up dog B is classified as such, etc). This may not necessarily mean classifying all pixels in the picture but rather only those that make up an object for analysis.

While their Deep Learning toolset was introduced around 2019, Esri (2023b) states that they have used machine learning in their software for over 20 years, most notably with the Spatial Analyst Extension toolset. Silicon valley's advances and rebrand mean this is now "AI", or in this case "GeoAI. Now, Esri offers a few licenses for AI/machine learning tools.

The use of Python in ArcGIS allows for the incorporation of some Deep Learning frameworks. This requires an Image Analyst license from Esri and the installation of some Python libraries – the latter is free, the former not. Esri also recommends (but doesn't require) that users have a CUDA-compatible GPU (CUDA being an Nvidia-specific software layer)(Wikipedia, 2023).

The Image Classification Wizard in ArcGIS Pro is a tool to help simplify this process. The wizard will guide users through developing training data, the training itself, and then using that model to analyze other data. It allows for either pixel-based classification – where each pixel is classified independent of those around it – or object-based classification – where each pixel is identified in partnership with its neighbours and as an overall object.

The webinar linked below (see Esri 2023b) will give more in-depth information about all of this – it should also be noted that the webinar is not a complete how-to, as many details are glossed over. Instead, it offers a "Look at this shiny new thing!" presentation. I was left with some questions about the value of the tool based on the examples. It might help the solitary worker who has funding to set up the model and leave it to train for a few hours, then analyze for a few hours. However, if you're a solitary worker, you may not have the time or funding to set that up, or have

the paid license. Moreover, there will still be work to verify and correct the output. It is useful for some users, though, or it wouldn't continue being developed.

One beneficial thing – Esri has several pre-made models that are now in their Living Atlas. Users can search "Deep Learning" in the Living Atlas to find those models for use in their own work. These are freely available to download or import to ArcGIS Pro.

Open-source options for GeoAI have proliferated in recent years as well. QGIS has several plugins in its repository. Various tools exist for object detection, segmentation, and analysis of raster and vector satellite and remote sensing data and point clustering on maps. Mapflow also has a plugin for QGIS that uses the Mapflow API (GISLounge, 2021). Various models are available for buildings, vegetation, roads, agriculture, etc.

Many sites exist that discuss the tools available, and as time goes on, these tools will become more user-friendly. As with many other AI systems, whether they will retain their capability as they do so, or whether they will remain financially accessible, remains to be seen. Furthermore, as with all things AI, the fundamental question remains: is this Good? This author can as yet offer no further knowledge.

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