The Role of Geospatial Technology and AI in Shaping Business Futures

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ABSTRACT

Geospatial technology is all about capturing, storing, processing and transforming obtained spatial and descriptive data into lucid, useful information that aids one in important decision making. Geospatial has gained significant traction for the ease of use and data inclusiveness thereby seamlessly incorporating and accepting a wide range of data collected in various formats into its Software systems. On the other hand, Artificial Intelligence (AI) though still in a nascent stage in developing countries is making quick inroads in numerous fields with the sole aim of reducing human labour involved in routine tasks. Though AI technology has an allegedly equal share of pros and cons, this paper attempts to extract the ways in which it's benefits can be tapped and utilized in Geospatial domain thereby making use of its core functionality to the completest.

Keywords: *Artificial Intelligence, AI applications, Geospatial technology, Machine Learning, Satellite imagery.*

I. INTRODUCTION

In layman's terms, Artificial Intelligence is a technological concept that performs certain automated tasks on its own with the trained patterns sans human intervention by using Machine Learning (ML) Algorithms such as Traditional Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN) or ConvNet. An AI system can have three perspectives namely,

- **Cognitive Intelligence:**

An ability that analyzes the past and present data's characteristics and performs analytical procedures to quantify expected behavior in the near future. Business and Weather forecasting Software systems function in this manner provided there is sufficient data volume. Analytical AI systems make use of this ability which resembles the cognitive functions of the human brain in predicting events.

- **Emotional Intelligence:**

The ability that tries to understand the emotional response of a person via his/her activity say vocal variations and create an appropriate environment accordingly. Human-inspired AI systems to tend to include both cognitive and emotional intelligence capabilities in them to receive organic inputs like voice commands and perform necessary analytical functions accordingly. Apple Iphone's Siri, a digital assistant that caters a user's needs augurs well for this category.

- **Social Intelligence:**

This ability is considered a summit point in AI domain that tries to mimic a human personality in the best possible way by incorporating the above-said abilities as well. Humanized AI systems such as Robots that are wired with three intelligent capabilities fervently mimic humans in terms of learning new skills and applying the same in problem-solving.

As for Geospatial domain is concerned, Cognitive Intelligence finds importance because of the myriad amount of data available to analyze and cull out meaningful outputs to make decisions especially when it comes raster-based analysis where the value of each and every pixel counts in extracting patterns that are normally obscured to the naked eye and further using them as inputs for implementing complex analytics.

II. METHODOLOGY

Now that an overall perception about AI technology and what it does is achieved, certain questions have been formulated and were tried to justify with regard to the Geospatial domain such as to find out its an actual necessity in the former, what are the complexities involved and so on.

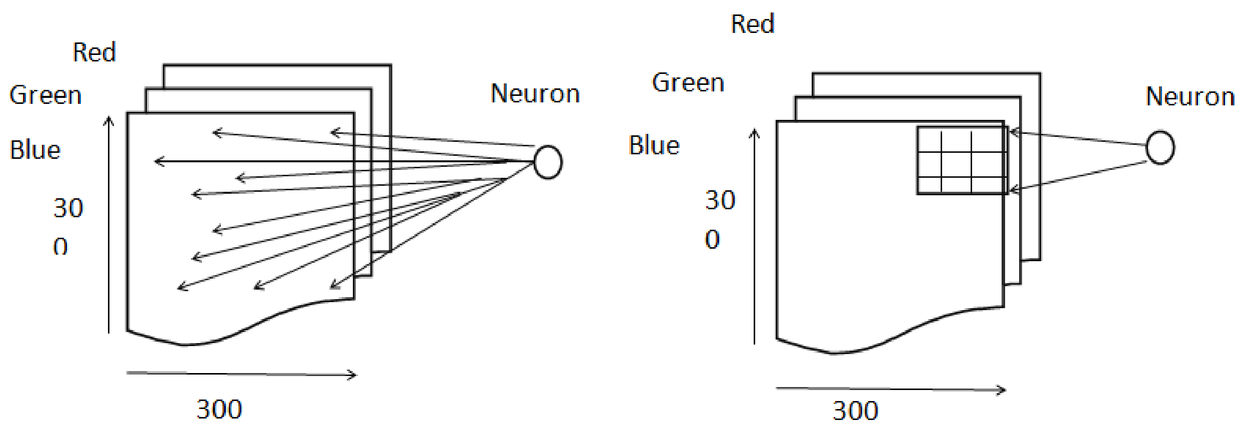
- How an Artificial Intelligence system actually works?
- Where does it find it's space in the Geospatial domain?
- What is it's Geospatial related applications?
- What is it's pros and cons?

Following sections were elaborated with respect to the order of the formulated questions.

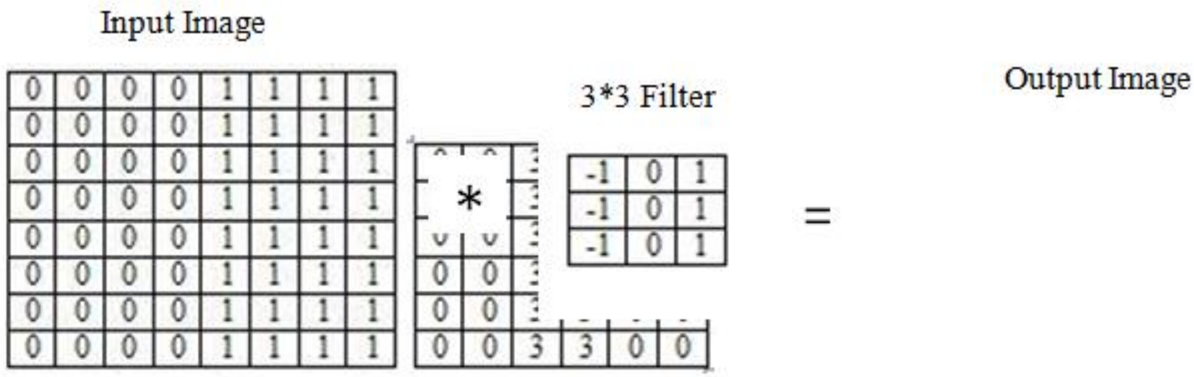
III. ANALYSIS

- **How AI Works?**

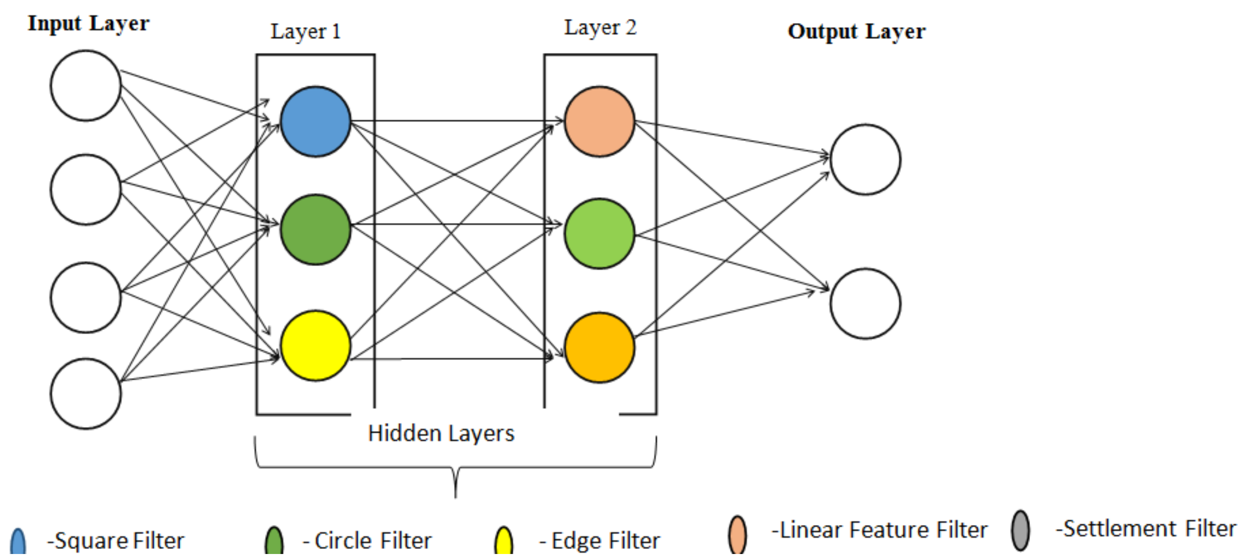
Though there are an innumerable amount of indigenously developed algorithms to suit specific needs, the one that assumes significance when it comes to analyzing visual imagery is Convolutional Neural Network (CNN). Let's consider an RGB color image with each color channel having 300 pixels and in order to analyze it using a Traditional Neural network algorithm each pixel of the image needs to be connected to a which literally means each neuron will have 2,70,000 (3*300*3) weights assigned to them cover the entire three-band image. This allocation and further analysis can betime-consuming and computationally intensive on lower grade computer systems and has paved the way for a crisp algorithm (CNN) that utilizes few neurons to cover the length and breadth of an image.



The difference between a traditional and convolutional neural network can be understood from the diagram where the former will have countless number of neurons with each having a number of weights proportional to the size of the image interconnected with each other in the hidden layers that function between a given input and produced output layer while a comparatively lesser number of neurons exist in the latter due to their bigger area of coverage. In CNN algorithm, the hidden layers are called the Convolutional layers that have neurons acting as Filters. These filters are the unique characteristic of a CNN that are used to detect and recognize patterns via performing a convolutional operation over the image of interest. The size of the filter (roughly called the Kernel) can be decided by the image analyst with the 3*3 matrix being the most commonly used. These filters are given weights in accordance with the nature of the task and slid over the image to eventually get a pixel value transformed image that may or may not is used for further manipulation. This procedure of transforming each and every pixel value of the input image into a new set of values is called Convolving an image. In order to better understand this, basic Convolutional operation is discussed further.



As one can observe the filter used here is a Vertical edge detector that nullifies the effects of smoothly varying surface while exaggerating the variant valued areas, after passing this filtered image through an Activation function which is nothing but a matrix emitting flash responses like white spots for bright valued pixels, a transformed image with pronounced vertical edges is achieved. For simpler illustration purposes, only a gray scale band of an image is used but the fundamentals remain the same for multi-band images with the exception of using multidimensional filters. Normally a CNN architecture tends to have rudimentary filters that detect shapes such as circles, squares and feature edges up front followed by more complex filters in the likes of feature-specific recognition such as human faces, cars etc drawing inspiration from how a human being's visual cortex functions proceeding from simple to complex interpretation of things.



Layers 1 and 2 are the Convolutional layers that can have n number of filters in them subject to user's discretion and it can be observed that shape detecting simple filters are stacked up front followed by categorical complex filters. Complex CNN architectures can have numerous hidden layers that gradually filter the input layer thereby getting deep insights and hence getting the name Deep Learning.

- **AI in Geospatial perspective**

As AI technology finds scope in raster-based analysis of imageries to discover patterns that go unnoticed in naked vision, an area where it assumes significance is the categorical classification of satellite imageries into different land cover classes with utmost accuracy provided there is a foolproof algorithm. A geospatially sound person might well be aware of two image classification techniques namely Supervised and Unsupervised where the former involves human supervision to train the classifier with apt training sets while the latter does it automatically by grouping similarly characterized pixels into different classes. This can be applied effectively in Land cover Mapping. Machine learning techniques are effectively applied in feature selection and feature extraction, while feature selection is just a pick and choose type where the subset of the original dataset is taken for analysis, feature extraction creates a new one altogether derived from the input. In an agriculture image trained models classifies the land cover classes such as buildings, roads, water, harvested, open land or bare land, forest, planted or dark cropland. Principle Component Analysis (PCA) is a feature extraction method that helps to solve the Curse of Dimensionality by omitting unnecessary variables/dimensions a dataset has and thereby trying to preserve the original essence of it using two dimensions. This can be a boon in reducing the size of imagery as well as detecting geological features such as Lineaments and fractures via the derived Principle components (PC) of an image.

Curse of Dimensionality:
As the name implies, too many variables can greatly alter a User's interpretability of an image, say for instance measuring the reflectance values for water, settlement and farm land classes in three bands and plotting them in a 3 D - Scatter plot can prove to be futile in finding out any concrete correlation among them. This has prompted for a dimensionality reduction technique (PCA) to determine PCs using which a 2D Scatter plot with PC1 as X-axis and PC2 as Y axis is drawn which helps to pool highly correlated pixels into groups called clusters that are eventually classified categorically. Since PCA is a mathematical concept and discussing it any further extends beyond the scope of this paper, it's theoretical significance in machine learning has been touched.

Geospatial Applications:
As for real-world application goes, AI can be utilized in two levels namely,

- One Level Applications
- Multi-Level Applications

One Level Applications:
Applications where machine learning techniques are used to fetch outputs that can single-handedly solve problems rather than acting as a tool in aiding further analytics. A common example would be the detection of specific objects by making use of interpretation keys such as size, shape, texture, pattern, etc. ERDAS Imagine, a remote sensing software allows one to perform Object-based imaged classification by making use of both spatial and spectral aspects if properly trained with reliable training sites.

Change detection, an analysis that exaggerates the temporally-variant areas by comparing two images acquired at different time periods utilizes a machine learning algorithm to denote output a binary classified image (an image with 0 and 1 classes with 0 indicating no change and 1 the vice versa) and multi-level classified image (categorically naming the change of land cover like water to land).

Multi-Level Applications:
As opposed to One level, Multi-level outputs act as building blocks for realizing the bigger picture. An output achieved using an algorithm will act as an input for subsequent more complex algorithms. By making use of an Object detection algorithm that detects Cars parked outside a Retail store and combining it's output with Socio economic status of the area that indicates factors such as purchasing power of customers and income levels, an estimate of the store's profit can be quantified which can be really helpful for its competitors to devise plans. Location based AI patterns can be used in financials transactions to find the customer spending pattern, the risk associated with the fraudulent transactions, data transparency has increased.Similarly, overall economic activity of reticent countries can be spied on by combining algorithmic outputs that detect the quantum of vehicles, ships and the cargos they carry, commercial centers using night illumination with statistical economic surveys like the Gross domestic product (GDP), percentage of working class, etc. In the technologly side, AI is used to restore the 3D buildings from aerial LiDAR. When the coefficients increases during the training even one can minimize the use of CNN.

- **Pros and Cons:**

Due to the advent of many commercial satellite launching outfits like SpaceX and Blue Origin the availability of high-quality satellite data has come abundant as opposed to yesteryears encouraging image analysts to adopt state of the art technologies to discover patterns that aid in problem-solving. Further due to its a myriad number of benefits in various domains ranging from business to agriculture intelligence AI has of late seen a sudden spurt driving business leaders and government agencies alike in investing a lot of money for research and development.

Though it proves to be a boon due to its X factor (Automation), the same can act as a bane for one sect of people searching for jobs. In developing Countries where unemployment is at its peak, automating tasks can drive it to lethal heights rendering many jobless and thus having a major impact on the economy. Moreover, there needs to be a development of powerful and reliable algorithms for one to trust otherwise they are as good as nothing.

IV. CONCLUSION

Artificial Intelligence, it's working nature, types and significance in geospatial technology have been briefly touched along with their real-world applications to get a better hold of it. Further, their benefits and shortcomings are pointed out with the balance slightly skewed towards the former. Though there remains a risk of unemployment in core sectors should there be an AI bloom, skill sets of the workforce should be harnessed by nurturing them with AI-related concepts for now so that they be better equipped for the coming thing.

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