

Capstone

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1 Geospatial Analysis

Geospatial data refers to data that identifies objects, events, or features based on their location on or near the Earth's surface. This type of data integrates location coordinates, attribute details describing the characteristics of the object or event, and temporal information indicating the time period during which the location and attributes are relevant.[4] This data can come from GPS, location sensors, social media, mobile devices, and satellite imagery. Geospatial analysis can help make trends regarding space and time more visually obvious than they would be in a massive set of raw data.

1.1 Geospatial Data Techniques

- **GIS (Geographic Information Systems) software** - This is a type of software that is designed for analyzing and visualizing geospatial data. Geographic data (also called spatial, or geospatial data) identifies the geographic location of features. These data include anything that can be associated with a location on the globe, or more simply anything that can be mapped. For example, roads, country boundaries, and addresses are all types of spatial data. At the CDC, we use GIS to help answer questions about how location impacts disease and disability.
- **Global Navigation Satellite System (GNSS)** - Global navigation satellite system (GNSS) is a general term describing any satellite constellation that provides positioning, navigation, and timing (PNT) services on a global or regional basis.[1]
- **Remote Sensing** - Remote sensing involves imaging of the Earth from aircraft or spacecraft at scales ranging from a few square kilometers to the entire globe. Images are formed from visible light as well as near-infrared light, thermal radiation, and microwave radiation, and thus extend well beyond the range of the human eye. The science of remote sensing involves extracting information from these images—for example, mapping vegetation properties over large areas. Geographic information systems (GIS) assist in the display and manipulation of spatial data—points, lines, or

areas with associated labels or data values. GIS is widely used by public agencies and private firms that have large land holdings or spatially distributed operations.[2]

1.2 Visualising Geospatial Data Techniques

The methods mentioned below are applied to various geospatial data sources, including satellite imagery, remote sensing data, and geographic information systems (GIS) data, to support a wide range of applications, such as land use planning, environmental monitoring, and public health surveillance.[7]

- **Spatial Interpolation (Kriging, IDW)** - These techniques estimate values for unknown locations based on known values.
- **Spatial Clustering (K-Means, Hierarchical Clustering, DBSCAN)** - These techniques are used to partition data into clusters based on similarity and identify dense clusters and noise points.
- **Spatial Regression (OLS, GWR, GLM)** - These methods are used to model the relationships between variables in space.
- **Spatial Classification** - This method involves assigning categories or labels to geographical or spatial data based on its attributes or characteristics.
- **Spatial Autocorrelation Analysis** - This technique is used to evaluate the relationship between the values of the same attribute in neighboring areas.

2 Applications of Geo-Spatial Techniques

- **Climate Change and Disaster** - Climate change and disaster management benefit greatly from the integration of GIS technologies, which bring together various disciplines to improve situational awareness and provide valuable insights for decision-making in mitigating, preparing for, and responding to natural disasters.[3]
- **Earth Observation Capabilities** - Earth observation capabilities are leveraged through remote sensing satellites to conduct a wide array of studies, monitoring processes such as vegetation biomass, phenology, water quality, and land and sea surface temperatures. These data hold significant promise for applications in forestry, agriculture, and disaster management.[3]
- **Healthcare Sector** - The healthcare sector has increasingly adopted geospatial tools and dashboards, particularly during the COVID-19 pandemic, to aid in monitoring contact tracing, containment zones, disinfection efforts, and support for migrants.[3]

- **Land and Resource Management** - GIS technologies play a crucial role in land and forest resource management, facilitating the creation of survey infrastructure for villages, accurate mapping, and generation of land records for rural planning. Additionally, remote sensing and GIS tools assist forest departments in mapping forest cover, assessing carbon stocks, and detecting forest fires and deforestation, thereby enhancing conservation and restoration efforts.[3]
- **Sociatal Problems** - Geospatial technologies are actively utilized to address diverse societal problems such as education, livelihood, financial inclusion, and environmental management.[3]
- **Logistics Issue** - In logistics, geospatial tools aid in tracking goods and ensuring their quality, while in transportation, they are instrumental in identifying locations, optimizing routes, and managing consignment navigation.[3]
- **Agriculture Use** - In agriculture, GIS technologies are applied to assess the vegetative state of selected areas, while in ecology, they help trace species populations and prevent or address environmental calamities.[3]
- **Weather Forecast** - Meteorological forecasts benefit from the use of geospatial technologies and tools, enabling accurate weather predictions for specific regions. [3]

3 Challenges in implementing AI and geospatial analysis for natural disaster prediction

Natural disasters, from hurricanes and earthquakes to wildfires and floods, have wreaked havoc on our planet for centuries. These catastrophic events can lead to immeasurable loss of life and property, and they often leave communities in ruins. While we cannot fully control or predict it, we can use the power of technology and innovation to mitigate the impact of these disasters. Artificial Intelligence (AI), with its remarkable capabilities, is emerging as a potent tool in disaster prevention, early warning, and response efforts. During a disaster, a large amount of data is generated from various sources including mobile communications, social media platforms (like Facebook, Twitter, Instagram, YouTube), sensors in Internet of Things (IoT) environments, and satellite imagery .[9] While acquiring this data is a crucial initial step in disaster preparedness, the key question is identifying the most appropriate information and communication technology (ICT) to effectively manage such situations. Fortunately, artificial intelligence (AI) is increasingly being utilized and its applications are expanding to encompass all kinds of disasters.

3.1 Limitations

- **Data Privacy and Security** - Data privacy and security are paramount, especially when it comes to systems that rely on gathering vast amounts of data like disaster prevention systems.[5]
- **Bias in AI** - Algorithmic bias, which refers to biases induced during the design and implementation of AI systems, is another critical difficulty. If algorithms are not thoroughly designed and evaluated, they may inadvertently amplify or add new biases to the data. AI algorithms must be prepared to be equitable, open, and accountable to address algorithmic prejudice.[8]
- **Accessibility and Equity** - Historically disadvantaged communities may have limited access to technology and resources, making them more vulnerable to natural disasters. Achieving equity involves not only providing access to AI tools but also addressing the underlying disparities in resources, infrastructure, and education that can exacerbate the impact of disasters on marginalized communities.[6]
- **Over reliance on Technology** - It's important to strike a balance between AI-assisted decision-making and human expertise, ensuring that AI complements, rather than replaces, the roles of emergency responders and disaster management professionals.[6]
- **Infrastructure and Resource Constraints** - International collaboration and support are needed to ensure that AI-driven disaster prevention technologies are accessible to all countries, regardless of their economic capabilities.
- **Accountability and Decision-Making** - When AI systems offer predictions or suggestions, it's important for them to be clear about how they reached those conclusions. Moreover, there should be avenues available to question or contest decisions made by AI. Particularly in situations where human lives and safety are on the line, it's essential to have systems in place that ensure AI is used responsibly and ethically, with oversight and accountability.

References

- [1] Gps.gov: Other global navigation satellite systems (gnss). (n.d.).
- [2] Remote sensing geospatial sciences — earth environment. (n.d.). © 2024 boston university.
- [3] Applications: India science, technology innovation, 2023.
- [4] Geospatial-data, 2023.

- [5] Muhammad Arslan, Ana-Maria Roxin, Christophe Cruz, and Dominique Ginhaç. A review on applications of big data for disaster management. In *2017 13th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)*, pages 370–375. IEEE, 2017.
- [6] Prof. Ahmed. Banafa. Artificial intelligence and natural disasters, 2023.
- [7] Luiz A Manfré, Eliane Hirata, Janaína B Silva, Eduardo J Shinohara, Mariana A Giannotti, Ana Paula C Larocca, and José A Quintanilha. An analysis of geospatial technologies for risk and natural disaster management. *ISPRS International Journal of Geo-Information*, 1(2):166–185, 2012.
- [8] Singh Sagar. Understanding bias in artificial intelligence: Challenges, impacts, and mitigation strategies.
- [9] D Velez and P Zlateva. Challenges of artificial intelligence application for disaster risk management. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 48:387–394, 2023.