Geomancer: Enhancing Geospatial Intelligence with a Natural Language-Assisted Mapping Interface

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ABSTRACT

This research introduces "Geomancer," an intuitive geospatial intelligence system that combines the capabilities of Large Language Models (LLMs) with an interactive map interface. The Geomancer application (app) supports military intelligence gathering and analysis, employing open-source and commercial LLMs to interpret and respond to queries. The app design originates from the user's hesitation to engage LLMs in extended typed conversation but their willingness to engage with visual maps. The user interface combines natural language with selectable areas of interest (AOI). The study evaluated Geomancer's capability to enhance operational efficiency and strategic decision-making in military applications. We built a basic evaluation framework for the app on three fundamental criteria: user interface friendliness, enhancement of operational productivity, and the analytical quality of geospatial data interpretation. We gauge user interface friendliness through usability studies, focusing on the system's intuitiveness, learning curve adaptability, and overall user satisfaction. We assess operational productivity enhancement by benchmarking task completion times and error rates against conventional geospatial intelligence systems. We explore the analytical quality based on the precision, contextual relevance, and depth of insights derived from the LLM with user-generated, map-based queries. We catalog and classify their interactions with the system with attention to the intuitiveness and efficiency of the interface, as well as the effectiveness of the natural language processing capabilities in handling geospatial inquiries. Challenges addressed in this study included the dependency on external APIs for geospatial data and the need to continuously refine the LLM's training dataset to ensure accuracy and relevance, particularly given the dynamic nature of military intelligence requirements and social media feeds. Integrating a natural language-driven interface with a user-friendly map, Geomancer provides an accessible, efficient, and accurate military intelligence tool, thereby enhancing geographic decision-making speed and outcomes.

ABOUT THE AUTHORS

David Noever has 27 years of research experience with NASA and the Department of Defense in machine learning and data mining. He received his Ph.D. from Oxford University, as a Rhodes Scholar, in theoretical physics and B.Sc. from Princeton University, summa cum laude, and Phi Beta Kappa. While at NASA, he was named 1998 Discover Magazine's "Inventor of the Year" for the novel development of computational biology software and internet search robots, culminating in co-founding the startup company cited by Nature Biotechnology as first in its technology class. He has authored more than 100 peer-reviewed scientific research articles and book chapters. He also received the Silver Medal of the Royal Society, London, and is a former Chevron Scholar. His primary research centers on machine learning, algorithms, and data mining for analytics, intelligence, and novel metric generation.

J. Wesley Regian has 32 years of experience in cognitive performance modeling and knowledge-based software technology development, primarily for military applications with AFRL, AFOSR, and DARPA. His work has supported over 50 fielded systems. He has published over 100 papers on intelligence analysis, human terrain modeling, knowledge representation, knowledge management, human learning, and memory, individual and developmental differences in human cognition, spatial ability and spatial information processing, cognitive modeling, skill acquisition, componential analysis of spatial tasks, cognitive automaticity, psychometrics, artificial intelligence, intelligent computer-based training, virtual reality, and multi-source intelligence fusion. Dr. Regian was a National Research Council research adviser for ten years and a Senior Scientist for Knowledge-Based Systems at the US Air Force Armstrong Research Laboratory.

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INTRODUCTION

In the mid-20th century, the amount of information needed to manage individual military units increased by 20 times (Naydenov, 2020). Manual methods could not keep up, thus significantly increasing the time and pre-deployment training needed for effective command decisions (Nossum et al., 2020; Juahsz and Guan, 2023). Geospatial Information Systems (GIS) govern troop movements and military logistics, effectively supporting these rapid command decision-making, planning combat operations, and various types of intelligence support for logistics and defense operations (Swann, 1999). The present research examines whether artificial intelligence (AI) -- specifically large language models or LLMs (Achiam et al., 2023)-- can augment human geospatial understanding and offload parts of this increasing cognitive load during pretraining or operational deployments (Li et al., 2020; Li and Ning, 2023). Figure 1 shows the final AI user interface developed for asking questions to maps interactively, including asking the AI for assistance locating nearby waypoints or describing complex satellite imagery.
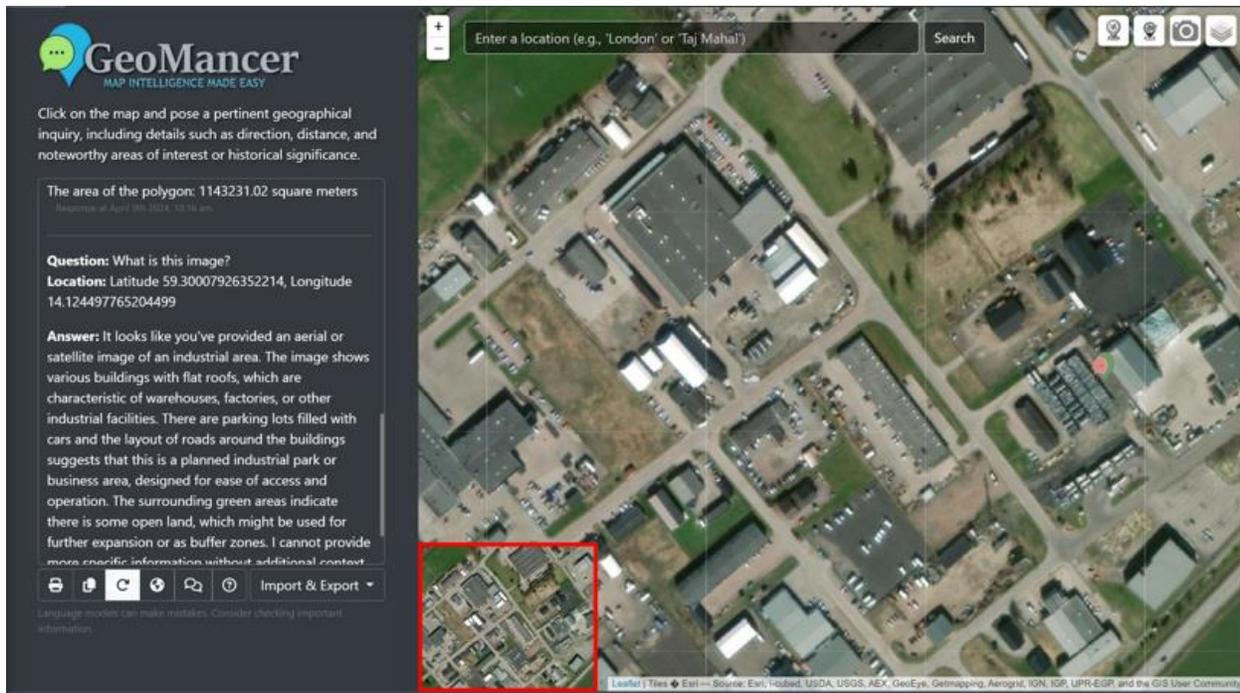

Figure 1. Interface to blend geographic information with large language model synthesizing capabilities.

The need for improved map interfaces. GIS plays a vital and expanding role in military operations globally, creating a strong need for well-trained military GIS specialists (Achlioptas et al., 2020). For example, since 2014, Russian forces have extensively used GPS spoofing to confuse and disorient Ukrainian troops and civilians (Baghai, 2024). By broadcasting fake GPS signals to show incorrect locations, both Russia and China have manipulated navigation systems (Bizyayeva, 2024). Along with aggressive electronic warfare, such geolocation spoofing highlights the need for well-trained military GIS specialists who can detect and counter such field tactics. Since the start of the 2002

Ukraine crisis, drones have also played a significant GIS role in the conflict for reconnaissance, surveillance, and mapping. Ukrainian forces have used drones to create detailed 3D maps of battlefields and identify enemy positions (Baghai, 2024). While defending their sovereignty, such real-time spatial information supports new situational awareness and decision-making (Jiang and Yang, 2024). Although currently geofenced outside AI deployment in an excluded combat geography, Ukrainian use of LLMs could assist in future map processing and analyzing vast drone

data, potentially identifying key features and patterns to support military decision-makers (Mooney et al., 2023). Furthermore, volunteer mapping efforts, such as those coordinated by the OpenStreetMap community, have provided valuable data on infrastructure, evacuation routes, and safe zones in Ukraine (Jiang and Yang, 2024). Military GIS specialists need to be able to integrate and validate such crowdsourced data with support from LLMs to filter and prioritize incoming data based on relevance and reliability (Barneche-Naya and Hernández-Ibáñez, 2023; Chen et al., 2024). Figure 2 shows an example query for AI interpretation of South China Sea locations recently added as reef islands for staging future military logistics.
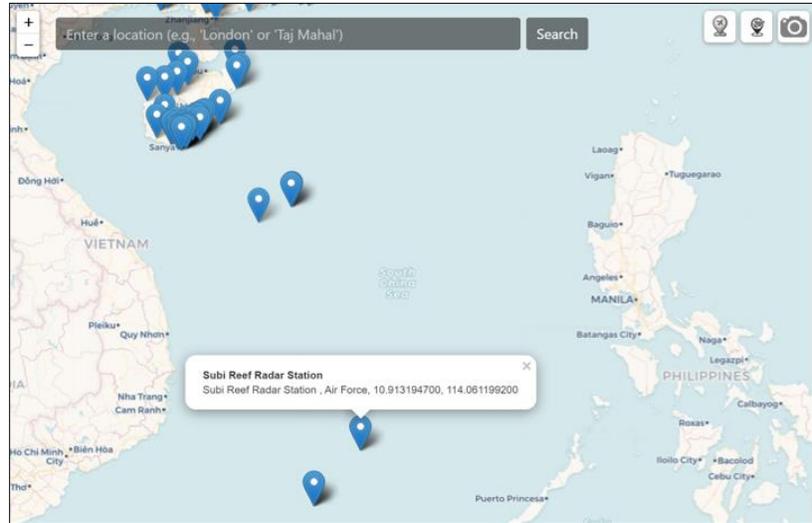
Figure 2. Tracking multiple points of interest in bulk with LLM interpretation

Finally, one AI-related hypothesis to test is whether GIS-based predictive models can help anticipate enemy movements, identify potential supply chain disruptions, and optimize resource allocation (Feng et al., 2023; Hao et al., 2024; Zhu et al., 2024). For instance, analysts have already used GIS to model the likely routes of Russian advances based on terrain, road networks, and other factors (Achlioptas et al., 2020). Training military GIS personnel in predictive modeling augmented with LLMs could assist by generating scenarios, suggesting relevant variables, and providing initial model interpretations (Krosnic and Oney, 20202; Li et al. 2020). When prompted for GIS inquiries, an example LLM answer uses only conversational natural language as inputs to identify nearby ports or air resupply depots.

The design goals of AI-map interfaces. Figure 3 highlights a typical LLM response given geospatial coordinates and a human question. While still an emerging technology, LLMs show the potential to assist in introductory GIS training and guiding problem-solving (Chen et al., 2024; Freider et al., 2024; Jiang and Yang, 2024; Juhasz and Guan, 2023). However, current limitations mean human expertise remains essential, especially for advanced mathematical topics and complex multi-step applications (Achiam et al., 2023; Feng et al., 2023). Close collaboration between military GIS experts and AI researchers assists the responsible development of this powerful technology (Frieder et al., 2024; Krosnick and Oney, 2023). Therefore, developing military-specific foundation GIS and language models integrating domain knowledge, as proposed with what this paper calls Geomancer, explore virtual assistants and tutors to support future military GIS training.

Figure 3. Example User Prompt for Contextual Localized Narratives

Previous Work and Gap Identification
Mooney et al. (2023) first quantified the spatial literacy of ChatGPT, a large language model (LLM) from OpenAI (Achiam et al., 2023), by testing it on adapted exams taken from a popular introductory GIS textbook. They found that without any special preparation or fine-tuning, both GPT3.5 and the more advanced GPT4 "could pass a balanced, introductory GIS exam, scoring 63.3% (GPT-3.5) and 88.3% (GPT-4), which correspond to grades D and B+ respectively in standard US letter

grading scale." Even the 2023 model could score near the top 10% of the mapping exam. Furthermore their results identified particular GIS strengths to build upon such as map interpretation, spatial statistics, and multi-step analysis. For example, the LLM could correctly draw a floodplain region based on five raw GIS sources ranging from terrain, census, road, demographics, FEMA emergency, and wetland environmental datasets. As suggested by earlier calls for predictive map interpretation, Hao et al. (2024) used LLMs to predict building collapses by analyzing news reports rather than official geo-hazard statistics, one of the only LLM predictors of future risky locations. Finally, Nossum et al. (2024) test

Figure 4. Seven types of maps ranging from terrain, satellite, street maps and 3D globes.

LLMs to understand geospatial file formats, most of which they struggled to interpret, including SOSI files, GeoPandas, GeoJSON, and ESRI shapefiles. Their study recommended longer context windows, standardized GIS tests, and vector embeddings for customizing prompts with more geographic context to overlay language understanding. As shown in Figure 4, these multi-map and multi-modal explorations generally highlight targeted GIS improvements in data interoperability, API integration, and geospatial task complexity, which are needed to realize the full potential of an effective GIS-LLM collaboration. For example, while LLMs generally perform well on combined mathematical and statistical word problems they can fail on more straightforward arithmetic or symbolic challenges (Frieder et al. 2024). Therefore, developing robust testing frameworks will also be critical to objectively measuring collaborative progress in future AI and human collaborative training.
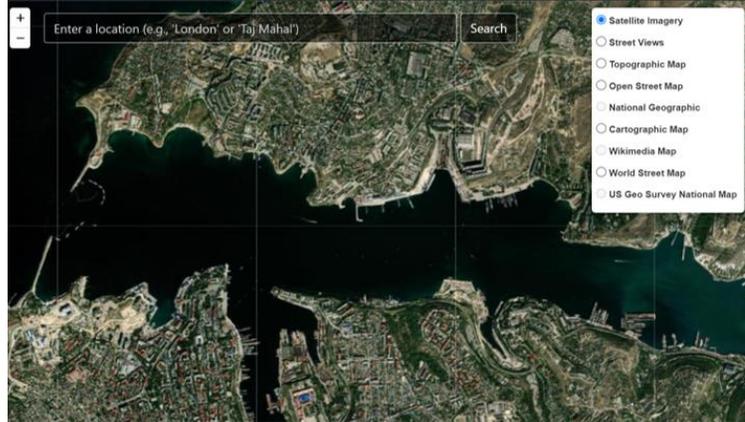
The Geomancer AI-LLM Fusion Application. This research effort initiated a project called Geomancer, a new web application that enables users to interact with geographical data and artificial intelligence. The web application integrates an interactive Leaflet map interface with the analytical LLM capabilities to provide an intuitive platform for users to explore and analyze geospatial data. The application supports various use cases, from military operations and disaster relief to environmental research and urban planning. The name choice for Geomancer is unrelated to an abandoned journalist application that provides a transparent, investigative mapping context (Associated Press, 2014) but shares a similar goal to merge natural language understanding with geo-coordinates. Geomancer gives users the ability to "interview" locations using the LLM. By clicking on a point on the map, users generate a contextual prompt based on the latitude and longitude, allowing the LLM to provide detailed, location-specific insights beyond standard map data. This feature transforms passive map viewing into an interactive learning experience, enabling users to access historical, cultural, and practical information about any point globally. As shown in Figure 5, the output of an extended conversation with a map-driven LLM captures artifacts to export for traditional military analysis in other three-dimensional globes like Google Earth, Cesium or ArcGIS.
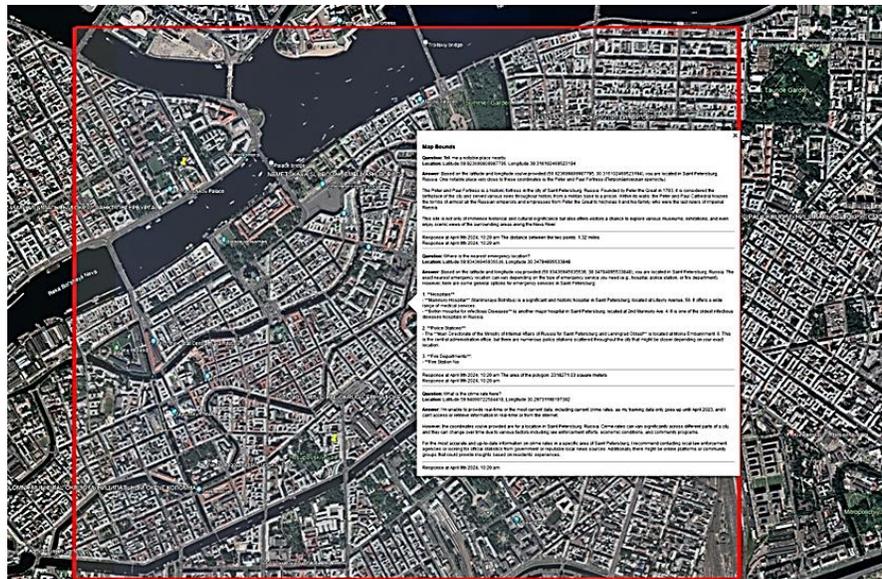

Figure 5. Exported Contextual Analytic as KML to Google Earth Summary

RESEARCH METHODS

Geomancer's system architecture consists of three main web components: front-end, back-end, and LLM integration. The user interface uses modern web technologies, including HTML, CSS, and JavaScript, and leverages the Leaflet library for interactive map rendering (leafljs.com, 2024). The server-side component handles user requests, processes spatial data, and communicates with the LLM. Geomancer integrates with an LLM, such as GPT-4 (Achiam et al., 2023)), through an Application Programming Interface or API. The LLM is trained on a vast geographic and historical data corpus to provide relevant and context-aware responses to user queries.

Map Customization and Data Layers

Geomancer allows users to customize the map display and toggle various data layers. Depending on their preferences and use case, users can choose from different base map options (Figure 4), including satellite imagery, OpenStreetMap, and contour maps. Geomancer supports the integration of multiple air, sea and space layers, such as transponders for Automatic Dependent Surveillance–Broadcast (ADS–B) and air traffic, marine automatic identification system, or AIS for ship locations, and satellite Two-line elements (TLE) for space objects. Leaflet's layer management functionality renders these layers on the base map as illustrated for ADS-B at Heathrow airport in Figure 6. The green plane icons represent in-air tracks versus the grey plane icons for grounded locations.

Data Import and Export

Geomancer includes tools for importing and exporting spatial data to enhance data interoperability and collaboration. Users can import KML files (Figure 5) and weather overlays to enrich the map with additional information. The application parses the imported data and renders it as a new layer on the main map. In addition to these imported locations, Geomancer allows users to export the current map view and associated data in various formats, including KML, GeoJSON, and CSV. This feature enables users to share their findings and integrate Geomancer's output with other GIS tools such as ArcGIS or Google Earth globes.

Figure 6. Contextual Air Navigation with Real-Time Data Overlays

*LLM Integration and Contextual Prompts*

As its main innovation, Geomancer integrates an LLM to enable conversational interactions with maps. Figure 7 highlights a user interaction from area selection to AI responses. When a user clicks on a location on the map, Geomancer captures the latitude and longitude coordinates of the click event. In this way, the application features military cursor-on-target capabilities but with the expected output yielding a conversational response rather than just tagging (Butler, 2005). These user-selected coordinates are then used to generate a contextual prompt for the LLM. The contextual prompts are crafted to include relevant information about the clicked location, such as nearby landmarks, historical events, or environmental characteristics. This prepended context helps the LLM provide more accurate and informative responses to user queries. Users can submit natural language queries related to the clicked location, and Geomancer sends these queries along with the contextual prompt to the LLM. The LLM generates a response based on its trained knowledge and the provided context, offering users valuable insights and information about the selected location.

Vision Language Modle (VLM) Integration for Satellite Imagery Analysis

Geomancer incorporates a VLM to enable advanced analysis and captioning of satellite imagery (Zhang et al, 2024). Users can access and display high-resolution satellite imagery within Geomancer. The application retrieves the imagery from various sources, such as Sentinel-2 or Landsat, based on the user's selected location and desired time. VLM is used to perform object detection and segmentation on the satellite imagery. It identifies and classifies various

features, such as buildings, roads, vegetation, and water bodies, providing users with a detailed understanding of the landscape composition. Geomancer employs the VLM to generate automatic captions for the satellite imagery. The VLM analyzes the image content and produces human-readable descriptions, highlighting key features and characteristics of the depicted area. The red box (lower middle in Figure 1) shows the screen capture of whatever the analyst might seek VLM assistance
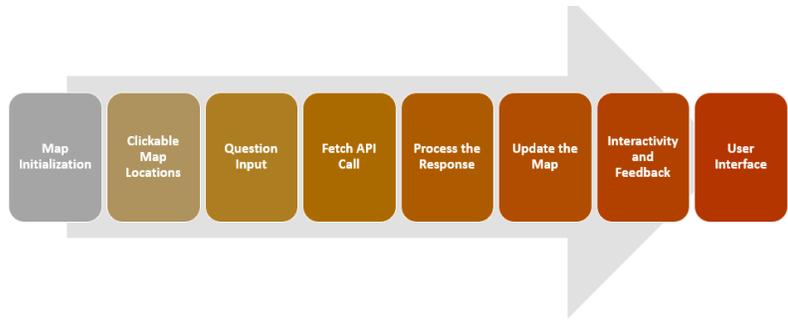
Figure 7. Workflow Diagram from Geographic Questions to Map Response

with identifying including object counting, scene recognition or damage assessments when the image is combined with a user question. This feature enhances the user's comprehension of the satellite imagery and facilitates data interpretation. Geomancer detects and highlights changes in land use, urban development, or environmental conditions by comparing satellite imagery from different periods. The VLM assists in identifying and quantifying these changes, enabling users to monitor and assess the evolution of specific locations over time.

Evaluation and User Feedback

To assess the effectiveness and usability of Geomancer, a usability and interface study was conducted: A diverse group of evaluations, including site loading, compliance and web design, were applied to test the application. Objective ratings were compared between Geomancer and existing popular GIS applications from Microsoft (Bing), Google (Maps), and ESRI (ArcGIS). The tests quantified the overall web task of location selection, site navigation to specific locations, and displayed spatial patterns, before engaging in conversational interactions with the map using the LLM integration. Table 1 shows seven evaluation tools applied to Geomancer and its GIS alternatives.

Testing Tool	Test Description
Lighthouse	Analyzes web pages and provides scores for performance, accessibility, best practices, and SEO. It offers suggestions for improvement and is available in Chrome DevTools
WebAIM's WAVE	Evaluates web content for accessibility issues, ensuring your design complies with Web Content Accessibility Guidelines (WCAG). It checks for common accessibility errors, such as missing alt text and low contrast.
PageSpeed Insights	Analyzes the content of a web page and generates suggestions to make the page faster on both mobile and desktop devices
GTmetrix	Analyzes a web page's speed performance, providing scores for PageSpeed and YSlow, along with recommendations for optimization
Solar Winds Pingdom	Tests the load time of a web page, analyzes its components, and provides performance insights and suggestions
Responsinator	Tests a website's responsive design by displaying it on multiple screen sizes and devices
W3C Markup Validation	Checks the markup validity of Web documents in HTML, XHTML, and more
Table 1. Objective Web Usability and Compliance Checkers for Comparison to other GIS Tools	

RESULTS

The usability study results in Table 2 indicated that Geomancer successfully integrates GIS and LLM technologies to provide an engaging and informative user experience. Objective scores for best practices, performance, search engine optimization and accessibility highlighted the application's ability to offer rapid and context-aware insights supporting various use cases, from military operations to environmental research. After using all seven tests in Table 1, the comparison chart shown for Page Speed Insights ranked Geomancer as first overall among four alternatives (Figure 8) with an average score of 90 combining application performance, conformity to best practices, accessibility and search engine optimization criteria.

Some research limitations and language-related areas for improvement were also identified, such as the need for more robust data validation and the handling of ambiguous or complex user queries.

Application	Performance	Best Practices	Search Engine Opt.	Accessibility	Integer Average
Geomancer	70	**100**	92	**96**	**90**
Google Maps	68	81	**100**	91	85
Bing Maps	69	96	92	89	87
ArcGIS	19	81	85	81	67
Open Street	**98**	81	85	79	86
Table 2. Evaluation of GIS User Interfaces Compared using Page Speed Insights					

Over 60 standard academic benchmarks have been applied for LLM validation, including specific subtasks (Eleuther, 2024). Called the Large Language Model Evaluation Harness, these benchmarks address some of the AI community's concerns with retrieval precision, accuracy, consistency, latency, and hallucination. Because our initial tests featured the current state of the art LLM (GPT4o, 2024), the research did not perform a detailed comparison to alternative language models. The main Geomancer advantage in using local open source models like Meta's LLAMA or Mistral (huggingface.co, 2024), center on cost, efficiency and whether the vision capabilities support satellite context. These findings will guide future development efforts to refine Geomancer's functionality and user interface.
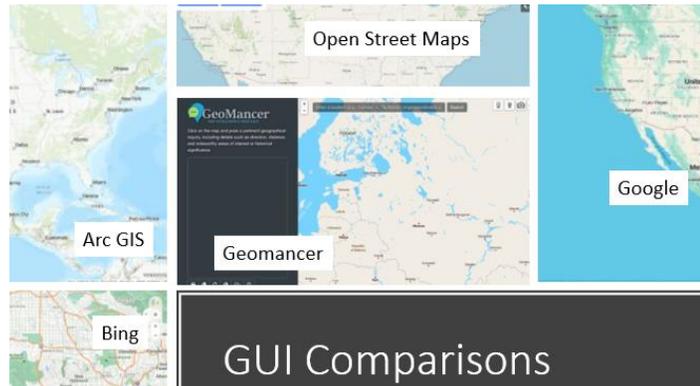

Figure 8. Comparative User Interfaces with Geomancer and Alternative GIS Applications

DISCUSSION

Integrating LLMs with geographic information systems (GIS) presents a novel approach to enhancing geospatial intelligence and decision-making. The Geomancer application, as introduced in this research, demonstrates the potential of combining natural language processing capabilities with interactive map interfaces. By enabling map analysts to "interview" locations using the LLM and generating contextual prompts based on latitude and longitude, Geomancer transforms passive map viewing into an interactive learning experience.

Data Sources and Availability. However, the development and implementation of such a system also present several challenges and limitations. One significant challenge is the dependency on external APIs for geospatial data. Geomancer relies on various data sources, such as satellite imagery, weather data, and real-time traffic information, to provide comprehensive insights (Figure 9). Ensuring these data sources' reliability, accuracy, and timely updates is crucial for the system's effectiveness. Inconsistencies or delays in data provisioning can impact the quality of LLM responses and the overall user experience.
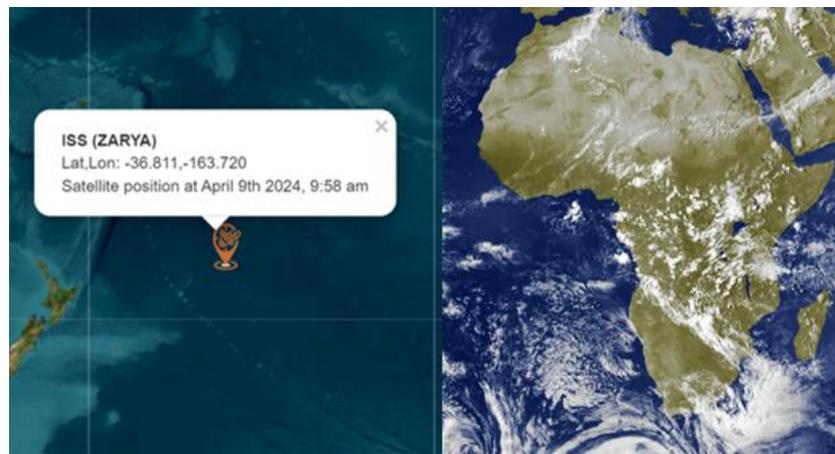

Figure 9. Global Satellite and Weather Overlays for Informed Decision Making

Recency and Privacy of LLM Training Data. Another challenge lies in the continuous refinement of the LLM's training dataset. The LLM's knowledge base must be regularly updated to ensure accuracy and relevance, particularly given the

dynamic nature of military intelligence requirements and social media feeds. This lagging input necessitates a robust data curation process that can filter and prioritize relevant information while maintaining the integrity and security of the system. Balancing the need for up-to-date information with the computational resources required for frequent retraining of the LLM is a significant consideration. When dealing with complex geopolitical contexts or rapidly evolving situations, the LLM may struggle to capture nuances or account for real-time changes in the geospatial landscape.

Furthermore, integrating LLMs with GIS raises concerns regarding data privacy and security. As Geomancer processes and analyzes sensitive geospatial information, it is essential to implement robust security measures to protect against unauthorized access, data breaches, or misuse of information. This tension includes strict access controls, encryption protocols, and compliance with relevant data protection regulations.

User Experience and Training. The user interface design also presents challenges in terms of usability and learnability. While Geomancer aims to provide an intuitive and user-friendly experience, the complexity of geospatial data and the range of features offered may require users to have a certain level of technical expertise. Striking the right balance between functionality and simplicity is crucial to ensure that users can effectively leverage the system's capabilities without being overwhelmed by its complexity.

Developing mechanisms for human oversight and validation of the LLM's outputs is necessary to mitigate these limitations. For example, China's GIS locations differ substantially from world standards (Bizyayeva, 2024), and significant Russian interference with GPS (Baghai, 2024, Figure 10) seems to make LLM interpretations contingent on input data quality and often vague international standards.

Figure 10. Mapping GPS Interference Zones Dynamically Based on Aircraft ADS-B Reported Errors in Position

CONCLUSIONS AND FUTURE WORK

Geomancer demonstrates the feasibility and potential benefits of integrating GIS with LLMs to create an intelligent and interactive platform for exploring and analyzing spatial data. By leveraging latitude-longitude click events to generate contextual prompts, Geomancer enables users to engage in natural language conversations with maps, unlocking insights and knowledge about specific locations. The design methods and tools employed in Geomancer's development, including web technologies, data import/export capabilities, and LLM integration, contribute to the application's flexibility and potential for supporting a wide range of use cases. As the field of GIS continues to evolve, integrating LLMs and conversational interfaces presents exciting opportunities for enhancing how users interact with and derive meaning from spatial data. We summarize the principal results as follows:

1. Geomancer demonstrates the feasibility of combining GIS with LLMs for interactive spatial data exploration and analysis.
2. Contextual prompts from latitude-longitude click events (cursor-on-target) enable natural language conversations with maps, unlocking location-specific insights.
3. The application's design, incorporating web technologies, data import/export capabilities, and LLM integration, contributes to its flexibility and potential for supporting various use cases.
4. Integrating LLMs and conversational interfaces in GIS presents opportunities for enhancing user interaction and deriving meaningful insights from spatial data, including usability comparisons and training metrics
5.

By expanding data sources, refining NLP techniques, exploring predictive analytics, improving user interaction, and addressing ethical considerations, Geomancer can evolve into a more comprehensive and trustworthy spatial data exploration and analysis system. These research directions align with the broader goals of advancing the field of GIS and harnessing the potential of AI and LLMs for geospatial applications.

ACKNOWLEDGEMENTS

REFERENCES

Achiam, J., Adler, S., Agarwal, S., Ahmad, L., Akkaya, I., Aleman, F. L., ... & McGrew, B. (2023). GPT-4 technical report. *arXiv preprint arXiv:2303.08774.* https://arxiv.org/pdf/2303.08774.pdf

Achlioptas, P., Abdelreheem, A., Xia, F., Elhoseiny, M., & Guibas, L. (2020). Referit3d: Neural listeners for fine-grained 3d object identification in real-world scenes. In *Computer Vision–ECCV 2020: 16th European Conference, Glasgow, UK, August 23–28, 2020, Proceedings, Part I 16* (pp. 422-440). Springer International Publishing.

Associated Press (2014), Geomancer, https://github.com/associatedpress/geomancer

Baghai, C. (2024), A New Dawn in Precision Warfare: How the US Air Force Plans to Outsmart Russian GPS Jamming, Medium, https://medium.com/@christianbaghai/a-new-dawn-in-precision-warfare-how-the-u-s-air-force-plans-to-outsmart-russian-gps-jamming-75c2c8ee1ab2

Barneche-Naya, V., & Hernández-Ibáñez, L. A. (2023). Assisted navigation for digital architectural walkthroughs in Natural User Interface-based installations. *Universal Access in the Information Society*, 1-15.

Bizyayeva, A. (2024), Every map of China is wrong …and this is intentional, Medium, https://medium.com/@anastasia.bizyayeva/every-map-of-china-is-wrong-bc2bce145db2

Butler, M. (2005). The developer's guide to cursor on target. *The MITRE Corporation. Bedford, MA*.

Chen, J., Xu, W., Cao, H., Xu, Z., Zhang, Y., Zhang, Z., & Zhang, S. (2024). Multimodal Road Network Generation Based on Large Language Model. *arXiv preprint arXiv:2404.06227.*

Eleuther AI, 2024. Language Model Evaluation Harness, https://github.com/EleutherAI/lm-evaluation-harness

Feng, Y., Ding, L., & Xiao, G. (2023). GeoQAMap-Geographic Question Answering with Maps Leveraging LLM and Open Knowledge Base (Short Paper). In *12th International Conference on Geographic Information Science (GIScience 2023)*. Schloss Dagstuhl-Leibniz-Zentrum für Informatik.

Frieder, S., Pinchetti, L., Griffiths, R. R., Salvatori, T., Lukasiewicz, T., Petersen, P., & Berner, J. (2024). Mathematical capabilities of chatgpt. *Advances in Neural Information Processing Systems*, *36*.

Hao, Y., Qi, J., Ma, X., Wu, S., Liu, R., & Zhang, X. (2024). An LLM-Based Inventory Construction Framework of Urban Ground Collapse Events with Spatiotemporal Locations. *ISPRS International Journal of Geo-Information*, *13*(4), 133.

HuggingFace.co (2024), Open LLM Leaderboard, https://huggingface.co/spaces/HuggingFaceH4/open_llm_leaderboard

Jiang, Y., & Yang, C. (2024). Is ChatGPT a Good Geospatial Data Analyst? Exploring the Integration of Natural Language into Structured Query Language within a Spatial Database. *ISPRS International Journal of Geo-Information*, *13*(1), 26.

Juhasz, L., & Guan, B. (2023). Utilizing Large Language Models in geographic contexts-Experiences from the FIU GIS Center. https://digitalcommons.fiu.edu/cgi/viewcontent.cgi?article=1104&context=gis

Krosnick, R., & Oney, S. (2022, September). ParamMacros: Creating UI Automation Leveraging End-User Natural Language Parameterization. In *2022 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)* (pp. 1-10). IEEE.

LeafletJS.com (2024), An Open-Source Javascript Library For Mobile-Friendly Interactive Maps, https://leafletjs.com/

Li, T. J. J., Mitchell, T., & Myers, B. (2020, July). Interactive task learning from GUI-grounded natural language instructions and demonstrations. In *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics: System Demonstrations* (pp. 215-223).

Li, Z., & Ning, H. (2023). Autonomous GIS: the next-generation AI-powered GIS. *International Journal of Digital Earth*, *16*(2), 4668-4686.

Mooney, P., Cui, W., Guan, B., & Juhász, L. (2023, November). Towards understanding the geospatial skills of ChatGPT: Taking a geographic information systems (gis) exam. In *Proceedings of the 6th ACM SIGSPATIAL International Workshop on AI for Geographic Knowledge Discovery* (pp. 85-94). https://eartharxiv.org/repository/view/5544/

Naydenov, K. (2020). The role of GIS in the military systems–some facts and issues. *International Multidisciplinary Scientific GeoConference: SGEM*, *20*(2.2), 437-444.

Nossum, A. S., Nomeland, A., & Aasgaard, R. (2024) LLMs-The Death of GIS Analysis?. https://kartai.no/wp-content/uploads/2024/01/Holm-2023-LLMs-The-Death-of-GIS-Analysis.pdf

Swann, David. "Military applications of GIS." *International Journal of Geographical Information Systems* 2.2 (1999): 889-899.

Zhang, J., Huang, J., Jin, S., & Lu, S. (2024). Vision-language models for vision tasks: A survey. *IEEE Transactions on Pattern Analysis and Machine Intelligence*.

Zhu, J., Dang, P., Cao, Y., Lai, J., Guo, Y., Wang, P., & Li, W. (2024). A flood knowledge-constrained large language model interactable with GIS: enhancing public risk perception of floods. *International Journal of Geographical Information Science*, 1-23.