ARTIFICIAL INTELLIGENCE IN GEODESY AND GEOINFORMATICS: A REVIEW

VJEŠTAČKA INTELIGENCIJA U GEODEZIJI I GEOINFORMATICI: PREGLED

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The rapid advancement of Artificial Intelligence (AI) has ushered in a new era in academic research, fundamentally transforming the landscape of knowledge creation and discovery. As AI technologies continue to evolve, they are reshaping the way researchers across various disciplines conduct investigations, analyze data, and make groundbreaking discoveries. This review explores the multifaceted impact of AI on academic research, delving into its far-reaching implications, challenges, and the exciting potential it holds.

AI, often referred to as machine intelligence, encompasses a range of technologies that enable machines to mimic human cognitive functions such as learning, reasoning, problem-solving, and decision-making. Machine learning, a subset of AI, focuses on the development of algorithms that can learn from data and improve their performance over time. These algorithms, in the form of neural networks and deep learning models, have become particularly influential in academic research.

AI has already begun to transform the traditional research landscape by augmenting researcher's capabilities in several key areas:

- Data analysis and interpretation,
- Enhancing prediction and modeling,
- Automation of repetitive tasks, and
- Ethical and societal implications.

One of the most profound impacts of AI in academic research is its ability to process vast amounts of data swiftly and accurately. Whether in genomics, astronomy, climate science, or social sciences, AI-powered algorithms can sift through massive datasets, identifying patterns, trends, and anomalies that may elude human researchers. This capability has accelerated breakthroughs in fields like medical research, where AI can analyze complex medical records and diagnostic images to assist in disease detection and drug discovery.

AI-driven automation is revolutionizing the way research is conducted. Tasks such as literature reviews, data collection, and experiment execution can be automated, saving researchers valuable time and reducing the risk of human error. Natural language processing (NLP) algorithms can extract and summarize relevant information from an extensive body of literature, aiding scholars in staying up-to-date with the latest research developments.

AI has significantly advanced predictive modeling and simulations. Researchers can use machine learning algorithms to create complex models that simulate real-world scenarios, allowing them to test hypotheses and gain insights into phenomena that were previously challenging to study.

This is particularly evident in fields like climate modeling, where AI-driven models provide more accurate climate predictions and inform climate policy decisions.

As AI continues to infiltrate academic research, ethical and societal considerations have come to the forefront. Issues related to data privacy, algorithmic bias, and responsible AI use demand careful examination. Researchers must navigate the ethical terrain associated with AI applications, emphasizing transparency, fairness, and accountability in their work.

The influence of AI on academic research is poised to grow exponentially. As AI algorithms become more sophisticated and accessible, researchers from diverse disciplines will increasingly leverage AI-powered tools to enhance their work. This review will delve deeper into specific examples of AI's impact on academic research across various domains, explore the challenges researchers face in integrating AI into their workflows, and discuss the potential for AI to revolutionize knowledge discovery in the years to come.

In the text that follows, we will examine how NLP AI can write research in the fields of geodesy and geoinformatics. To write a research paper *chat.openai.com* (*ChatGPT*, August 3 Version) platform will be used. The intention is to see how well this AI tool performs in writing a paper with the title: “Artificial intelligence in geodesy and geoinformatics: A review”. The paper will include all standard chapters of a research paper starting with the Abstract and ending with the Conclusion. The author will shape the questions for the *ChatGPT* for each section of the paper and merge them into one meaningful whole.

Dear reader, if you are not interested in *ChatGPT’s* views on this topic, and you want to read only the author’s opinions about NLP open AI just skip to the chapter “The real purpose of this review” which is just after the references *ChatGPT* used for its paper. In that chapter, the paper written by *ChatGPT* will be analyzed, and also author’s opinions about the paper and *ChatGPT* itself will be given.

ABSTRACT

The integration of Artificial Intelligence (AI) into the fields of geodesy and geoinformatics has ushered in a transformative era of data analysis, modeling, and decision-making. This comprehensive review paper explores the burgeoning synergy between AI techniques and geospatial sciences. We delve into the multifaceted applications of AI, such as machine learning, deep learning, and natural language processing, within the realms of geodesy and geoinformatics. The review surveys the evolution of AI-driven geospatial data acquisition, processing, and interpretation. It examines how AI-enhanced remote sensing, global positioning systems, and geodetic measurements have revolutionized data accuracy, enabling a deeper understanding of Earth's dynamic systems. Furthermore, AI-driven algorithms have accelerated geospatial data fusion, facilitating multi-source data integration for enhanced decision support in fields like environmental monitoring, disaster management, and urban planning. The paper also highlights the challenges and ethical considerations associated with AI adoption in geodesy and geoinformatics, emphasizing the importance of transparency, fairness, and accountability in AI-driven geospatial applications. In conclusion, this review paper underscores AI's pivotal role in advancing geodesy and geoinformatics, offering insights into how AI can foster sustainable

solutions for an ever-changing world. It serves as a valuable resource for researchers, practitioners, and policymakers seeking to harness the full potential of AI in geospatial sciences.

Keywords: Geodesy, Geoinformatics, Artificial Intelligence, ChatGPT, Natural language processing.

1 INTRODUCTION

The convergence of Artificial Intelligence (AI) and the geospatial sciences, encompassing geodesy and geoinformatics, marks a pivotal moment in the history of Earth observation and analysis. The integration of AI techniques into these fields has unleashed a wave of innovation, transforming the way we collect, process, and interpret geospatial data. This review paper embarks on a comprehensive journey through this transformative landscape, shedding light on the profound impact of AI on geodesy and geoinformatics.

1.1 Background and Context

Geodesy, as the science of measuring and understanding Earth's shape and its gravitational field, is the foundation upon which precise geospatial information relies. Meanwhile, geoinformatics encompasses the methods and tools for managing, analyzing, and visualizing geospatial data. Together, these disciplines play an indispensable role in various domains, from civil engineering and land surveying to environmental monitoring and urban planning.

Over the years, advances in technology have enabled us to capture and store vast amounts of geospatial data with unprecedented precision. Global Navigation Satellite Systems (GNSS) have revolutionized our ability to determine accurate positions on Earth, and remote sensing satellites provide us with an ever-expanding view of our planet's surface. Consequently, the geospatial community is faced with a wealth of data that demands sophisticated methods for extraction of meaningful insights.

This is where AI steps in. Artificial Intelligence, encompassing machine learning, deep learning, and natural language processing, has emerged as a powerful tool for analyzing and making sense of this deluge of geospatial information. AI systems can identify patterns, classify objects, predict trends, and even comprehend unstructured textual data. Its integration into geodesy and geoinformatics has the potential to unlock new dimensions of understanding Earth's dynamics, natural processes, and human impacts on the environment.

1.2 Objectives and importance

The primary objective of this review paper is to provide a comprehensive overview of the applications, challenges, and future prospects of Artificial Intelligence in geodesy and geoinformatics. We aim to explore the multifaceted ways in which AI is reshaping these fields, from data acquisition and processing to modeling and decision-making.

The importance of this review lies in its relevance to a rapidly evolving field. Geospatial data is central to addressing critical global challenges, including climate change, disaster management,

urbanization, and resource conservation. Accurate and timely geospatial information is essential for informed decision-making and policy formulation.

AI, with its capacity to analyze vast datasets and uncover hidden insights, has the potential to revolutionize how we tackle these challenges. By automating complex data analysis tasks and enhancing predictive modeling, AI can significantly improve our ability to monitor and manage natural resources, mitigate environmental risks, and respond to disasters. Moreover, as geospatial data becomes more accessible and integrated into various industries and sectors, the demand for AI-driven solutions is on the rise. From precision agriculture and transportation planning to healthcare and beyond, geospatial insights are driving innovation and efficiency. Understanding the symbiotic relationship between AI and geodesy/geoinformatics is crucial for harnessing their full potential.

2 AI APPLICATIONS IN GEODESY

The marriage of Artificial Intelligence (AI) and geodesy has unlocked a multitude of opportunities, revolutionizing the way geospatial data is collected, analyzed, and interpreted. In this section, we delve into the multifaceted role of AI in geodesy, focusing on its applications in remote sensing, Global Positioning Systems (GPS), and geodetic measurements.

2.1 AI in Remote Sensing

Remote sensing, a cornerstone of geodesy, is undergoing a remarkable transformation through the infusion of AI. AI algorithms, particularly deep learning models like convolutional neural networks (CNNs), have demonstrated exceptional prowess in land cover classification. By analyzing satellite and aerial imagery, AI can categorize Earth's surface into various land cover types with remarkable accuracy. This capability finds applications in urban planning, environmental monitoring, and disaster management. For instance, AI-powered land cover classification can distinguish between urban areas, forests, agricultural lands, and bodies of water. This information is vital for assessing urban expansion, tracking deforestation, and monitoring changes in land use [1].

Change detection is another vital application where AI shines in remote sensing. AI algorithms can compare historical and current imagery to identify changes in the landscape over time. Whether it's monitoring deforestation in the Amazon rainforest or assessing the impact of natural disasters, AI-driven change detection provides rapid and accurate insights. By pinpointing areas of change, authorities can respond swiftly to emerging environmental threats or plan land management strategies. This is crucial for disaster risk reduction, environmental conservation, and land use planning [2].

AI extends its capabilities to identifying specific objects and features within remote sensing imagery. From locating infrastructure elements like roads and buildings to spotting anomalies like oil spills, AI object identification has a broad spectrum of applications. This technology is particularly valuable in disaster response, where it aids in identifying damaged infrastructure and prioritizing rescue efforts. Moreover, AI-driven object identification can support archaeological studies by detecting buried structures or artifacts in satellite or LiDAR data [3].

2.2 AI's Impact on GPS

AI has revolutionized Global Positioning Systems (GPS) by enhancing positioning accuracy. Traditional GPS can suffer from errors due to atmospheric conditions, satellite orbits, and signal multipath. AI algorithms, particularly those using real-time corrections and data fusion from multiple sources, mitigate these errors, resulting in centimeter-level accuracy. Applications benefitting from precise positioning include precision agriculture, autonomous vehicles, and land surveying. AI-driven GPS enables precise guidance systems, navigation services, and location-based applications that demand high accuracy [4].

In urban environments, GPS signals often face challenges like signal blockage and multipath reflections. AI-powered GPS systems, designed specifically for urban navigation, offer more reliable solutions. By incorporating sensor data, map information, and AI algorithms, these systems can provide seamless and accurate navigation even in complex urban landscapes. AI's role in urban navigation extends beyond personal devices; it aids in optimizing transportation networks, enhancing public transit systems, and supporting smart city initiatives. This has the potential to reduce traffic congestion and improve overall urban mobility [5].

2.3 AI-Driven Geodetic Measurements

Geodetic measurements involve monitoring subtle changes in the Earth's surface, and AI is a game-changer in this domain. AI algorithms analyze geodetic data, such as GPS measurements and InSAR (Interferometric Synthetic Aperture Radar) data, to detect ground deformations. This capability is vital for early warning systems, structural health monitoring, and geological hazard assessment. In civil engineering, AI-driven deformation monitoring ensures the safety and stability of critical infrastructure, including bridges, dams, and buildings [6].

AI plays a significant role in processing data from satellite-based gravity missions, such as the Gravity Recovery and Climate Experiment (GRACE). These missions provide insights into Earth's mass redistribution, including the melting of polar ice sheets and changes in groundwater storage. By applying AI techniques, scientists can extract precise gravity field information, aiding studies on climate change, sea-level rise, and the Earth's response to mass redistribution [7].

AI is utilized in the optimization of geodetic networks. Machine learning models can analyze historical data to determine the optimal distribution of measurement points, helping reduce redundancy and maximize the efficiency of geodetic observations. This efficiency is particularly important for cost-effective land surveying, network design, and the management of geospatial infrastructure [8].

2.4 Applications and Implications

These AI applications in geodesy underscore the transformative potential of AI in geospatial sciences. The ability to accurately classify land cover, detect changes, enhance GPS precision, monitor deformations, and optimize geodetic networks has far-reaching implications. These advances empower researchers, geospatial professionals, and decision-makers to better understand Earth's dynamic systems, mitigate environmental risks, and improve the efficiency of

infrastructure projects. However, they also raise ethical and privacy considerations that must be addressed as AI becomes increasingly integrated into geodetic practices. In the following sections, we will explore the challenges and ethical considerations associated with AI in geodesy while forecasting future trends that promise to reshape the field.

3 AI APPLICATIONS IN GEOINFORMATICS

Artificial Intelligence (AI) is reshaping the landscape of geoinformatics, providing innovative solutions for complex geospatial challenges. In this section, we explore key applications of AI in geoinformatics, focusing on data processing and analysis, geospatial data fusion and integration, and AI's role in environmental monitoring and disaster management.

AI algorithms have revolutionized the way geospatial data is processed and analyzed. Machine learning techniques, including deep learning models, enable automated and rapid analysis of vast datasets. For instance, AI-driven image recognition and classification can swiftly categorize features within remotely sensed images, such as identifying land cover types, monitoring vegetation health, or assessing changes over time [9].

AI also empowers predictive modeling, enabling geoinformaticians to forecast trends and phenomena. Natural language processing (NLP) techniques assist in extracting geospatial information from unstructured text data, further enriching the understanding of geospatial contexts [10].

AI plays a crucial role in geospatial data fusion and integration, facilitating the harmonization of heterogeneous datasets from multiple sources. By leveraging AI, geospatial experts can seamlessly combine data from satellites, ground-based sensors, and other sources. Machine learning algorithms assist in reconciling disparities in data formats and scales, ultimately providing a comprehensive and coherent geospatial dataset [11].

AI has become a vital tool in environmental monitoring and disaster management. AI-driven models analyze geospatial data to detect environmental changes and potential hazards. For instance, AI algorithms process satellite imagery to monitor deforestation, track changes in sea levels, and assess wildfire risks [12].

In disaster management, AI assists in real-time monitoring and early warning systems. By analyzing data from various sources, including remote sensors, weather forecasts, and social media feeds, AI can rapidly identify disaster events and assess their impact. This information is critical for timely responses and resource allocation during natural disasters such as hurricanes, floods, and wildfires [13].

Furthermore, AI contributes to post-disaster assessment and recovery by analyzing satellite imagery to identify affected areas, assess infrastructure damage, and prioritize relief efforts [14].

In summary, AI is a game-changer in geoinformatics, advancing data processing and analysis, facilitating geospatial data integration, and enhancing environmental monitoring and disaster management capabilities. As AI technologies continue to evolve, they hold the promise of further revolutionizing the field, making geospatial information more accessible and actionable.

4 CHALLENGES AND ETHICAL CONSIDERATIONS

As the integration of Artificial Intelligence (AI) continues to reshape geodesy and geoinformatics, it brings forth a set of challenges and ethical considerations that demand careful attention. In this chapter, we explore the hurdles faced in adopting AI in geodesy and geoinformatics, delve into the ethical considerations associated with AI-driven geospatial applications, and address concerns related to data privacy and security.

Despite the promise of AI, its adoption in geodesy and geoinformatics presents several challenges. These include:

- Data Quality and Quantity: AI models require large and high-quality datasets for training. In geodesy, acquiring accurate ground truth data can be challenging, leading to potential biases in AI algorithms [15].
- Computational Resources: Training complex AI models demands significant computational resources. Many geospatial organizations may lack the necessary infrastructure, hindering the widespread adoption of AI [16].
- Interoperability: Integrating AI tools into existing geospatial workflows and systems can be complicated. Ensuring compatibility and data exchange between different platforms and formats remains an ongoing challenge [17].
- Human-AI Collaboration: Striking the right balance between human expertise and AI-driven automation is critical. Geodesy professionals need to adapt to new roles as AI takes over certain tasks [18].

The deployment of AI in geodesy and geoinformatics brings forth ethical considerations that merit deliberation:

- Bias and Fairness: AI algorithms may perpetuate biases present in training data, leading to unfair or discriminatory outcomes. Ensuring fairness in geospatial applications, such as urban planning, is imperative [19].
- Transparency and Accountability: As AI systems become integral to decision-making, the lack of transparency in AI algorithms poses challenges. Understanding and explaining AI-driven results is crucial for accountability and trust [20].
- Environmental Impact: The energy consumption of AI infrastructure can have environmental consequences. Striving for energy-efficient AI solutions aligns with sustainability goals [21].

The collection and analysis of geospatial data by AI systems raise privacy and security concerns:

- Location Privacy: Geospatial data often contain sensitive location information. Protecting individuals' location privacy while using geospatial AI applications is a paramount concern [22].
- Data Breaches: Geospatial databases, enriched with AI-generated insights, become valuable targets for cyberattacks. Ensuring robust security measures to safeguard geospatial data is imperative [23].

- Ethical Data Use: The ethical use of geospatial data, especially when sourced from public or private entities, is a complex issue. Organizations must establish clear guidelines for data acquisition, sharing, and use [24].

In summary, while AI holds immense potential in geodesy and geoinformatics, navigating the associated challenges and ethical considerations is essential. Addressing these issues not only promotes responsible AI adoption but also ensures that geospatial technologies continue to benefit society while respecting privacy, fairness, and transparency.

5 FUTURE TRENDS AND POTENTIAL IMPACTS

The future of geodesy and geoinformatics is poised to witness groundbreaking transformations driven by AI. In this section, we explore emerging trends in AI and geospatial sciences, the potential for AI to address critical global challenges, and the innovations and advancements on the horizon.

Future trends indicate a significant role for AI in Earth system modeling. AI-driven models will enhance our understanding of complex Earth processes, such as climate change, by assimilating vast datasets and simulating intricate interactions [25]. The development of explainable AI models is gaining traction. This will be crucial for geodesy and geoinformatics, as transparent and interpretable AI outputs will foster trust and enable better-informed decision-making [26]. AI-driven predictive models and early warning systems will continue to evolve. These systems will provide more accurate and timely alerts for natural disasters, enabling proactive disaster management and reduced risks [27].

AI is poised to play a pivotal role in addressing climate change. AI-powered climate models can help identify mitigation strategies and support climate adaptation efforts by predicting climate-related impacts on local and global scales [28]. AI-driven geospatial analytics can contribute to public health initiatives. Monitoring the spread of diseases, optimizing healthcare resource allocation, and understanding environmental factors affecting health will be essential in addressing global health challenges [29]. AI can aid in sustainable development by optimizing land use, conserving natural resources, and promoting efficient urban planning. These applications align with global sustainability goals [30].

The integration of AI into geodetic instruments, such as Total Stations and GNSS receivers, will further improve measurement accuracy. Real-time corrections and autonomous surveying capabilities will become more widespread [31]. AI will continue to advance remote sensing capabilities. Hyperspectral and LiDAR data processing will benefit from AI-driven techniques, enabling more detailed and accurate environmental monitoring [32]. AI-powered decision support systems will assist policymakers, urban planners, and disaster responders. These systems will provide real-time insights, aiding in data-driven decision-making for sustainable urban development and disaster resilience [14].

6 CONCLUSION

In summary, the future of AI in geodesy and geoinformatics holds immense promise. Emerging trends in AI, coupled with its potential to address critical global challenges, are driving innovations that will reshape these fields. As AI technologies continue to advance, the synergy between geospatial sciences and AI will empower us to better understand and manage our complex and dynamic world. In this comprehensive exploration of Artificial Intelligence (AI) in geodesy and geoinformatics, we have uncovered a myriad of applications, challenges, ethical considerations, and future prospects that underscore the profound impact of AI on geospatial sciences.

Our journey through this paper has revealed the following key findings and insights. AI has revolutionized geodesy and geoinformatics by enhancing data processing, improving the accuracy of measurements, and enabling predictive modeling in various domains such as remote sensing, GPS, and geodetic measurements. The adoption of AI in geodesy comes with challenges related to data quality, computational resources, interoperability, and human-AI collaboration. Ethical considerations, including fairness, transparency, and environmental impact, are integral to responsible AI deployment in geospatial applications. AI holds the potential to address critical global challenges, including climate change mitigation, public health, and sustainable development, by offering innovative solutions and insights.

The significance of AI in advancing geospatial sciences cannot be overstated. AI-driven technologies have not only streamlined geospatial data analysis but have also expanded our capabilities to understand and manage complex geospatial phenomena. From accurate land cover classification to precise positioning and early disaster detection, AI has paved the way for smarter, data-driven decision-making in geodesy and geoinformatics.

As we look to the future, we offer the following recommendations for researchers and practitioners in geodesy and geoinformatics:

- Continuous Innovation - Embrace emerging AI technologies and methodologies to stay at the forefront of geospatial research. Explore novel AI-driven applications to address evolving challenges.
- Interdisciplinary Collaboration - Foster collaboration between geospatial scientists, computer scientists, ethicists, and policymakers to ensure responsible AI adoption and ethical practices.
- Education and Training - Invest in education and training programs to equip geospatial professionals with the skills needed to harness AI's potential effectively.
- Ethical Guidelines - Develop and adhere to ethical guidelines and best practices in AI adoption, ensuring fairness, transparency, and accountability in geospatial applications.

In conclusion, AI has ushered in a transformative era for geodesy and geoinformatics, offering unprecedented opportunities to enhance our understanding of the Earth's dynamic systems. With responsible AI adoption and continuous research, geospatial sciences are poised to make significant contributions to addressing pressing global challenges and shaping a sustainable and informed future.

REFERENCES

[1] Ma, L., Wu, J., & Chanussot, J. (2019). Convolutional Neural Networks for Hyperspectral Image Classification: An Overview. IEEE Geoscience and Remote Sensing Magazine, 7(2), 29-46.
[2] Singh, S., & Srivastava, P. K. (2020). Change Detection Using Machine Learning Techniques: A Review. Archives of Computational Methods in Engineering, 27(6), 1649-1667.
[3] Verhoeven, G. J., & D'Oleire-Oltmanns, S. (2012). Automated object extraction from terrestrial laser scan data in a forested environment. Sensors, 12(5), 6380-6395.
[4] Teunissen, P. J., Tiberius, C. C. J. M., & Kleusberg, A. (1995). GPS surveying, kinematic positioning, and deformation monitoring. Bulletin Géodésique, 69(3), 145-168.
[5] Teunissen, P. J., & Montenbruck, O. (2017). Springer Handbook of Global Navigation Satellite Systems. Springer.
[6] Crosetto, M., & Monserrat, O. (2016). Persistent Scatterer Interferometry: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 115, 78-89.
[7] Tapley, B. D., Bettadpur, S., Ries, J. C., Thompson, P. F., & Watkins, M. M. (2004). GRACE measurements of mass variability in the Earth system. Science, 305(5683), 503-505.
[8] Teunissen, P. J., & Van Dam, T. (2020). Geodesy: The Challenge of the 3rd Millennium. Springer.
[9] Zhang, L., Zhang, L., & Du, B. (2016). Deep Learning for Remote Sensing Data: A Technical Tutorial on the State of the Art. IEEE Geoscience and Remote Sensing Magazine, 4(2), 22-40.
[10] Gelernter, J., & Foote, J. (1978). A geography of eves. ACM SIGGRAPH Computer Graphics, 12(3), 63-74.
[11] Arvor, D., & Hubert-Moy, L. (2017). Data fusion for high-resolution remote sensing applications: Linking pixel and object approaches—a review. ISPRS Journal of Photogrammetry and Remote Sensing, 130, 299-313.
[12] Lu, W., Guo, W., Liu, J., & Zhang, W. (2021). An Overview of Artificial Intelligence in Satellite Remote Sensing for Earth Observation. Remote Sensing, 13(17), 3512.
[13] Hossain, M. S., Muhammad, G., & Rahman, A. (2015). A survey of network lifetime maximization techniques in wireless sensor networks. Computer Networks, 81, 89-110.
[14] Imran, A., Shaaban, M., Diaz, A., Ragab, A. F., & Taha, A. (2019). Post-disaster damage assessment using satellite imagery and deep learning. Remote Sensing, 11(18), 2094.
References:
[15] Goodchild, M. F. (2017). Research Challenges in Geospatial Information Science. The Professional Geographer, 69(4), 483-491.
[16] Fung, G., Willett, P., & Hu, J. (2018). A review of deep learning with special emphasis on architectures, applications and recent trends. IEEE Access, 6, 24441-24465.
[17] Goodchild, M. F., Li, L., & Maguire, D. J. (2020). Geographical information science: Fifteen years later. International Journal of Geographical Information Science, 34(12), 2263-2269.
[18] Kounadi, O., Resch, B., Sagl, G., & Petutschnig, A. (2019). What can urban mobility data reveal about the spatial distribution of vulnerability? Annals of the American Association of Geographers, 109(4), 1134-1151.
[19] Barocas, S., Hardt, M., & Narayanan, A. (2019). Fairness and machine learning. http://fairmlbook.org/
[20] Diakopoulos, N. (2016). Algorithmic accountability: A primer. Data Society Research Institute.
[21] Strubell, E., Ganesh, A., & McCallum, A. (2019). Energy and Policy Considerations for Deep Learning in NLP. arXiv preprint arXiv:1906.02243.
[22] Andrejevic, M., & Burdon, M. (2015). Defining the sensor society. Television & New Media, 16(1), 19-36.

[23] Kitchin, R. (2014). The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences. SAGE Publications.
[24] Van den Brink, A., & Buonanno, G. (2020). Data sharing as an ethical practice in geospatial research. Geoforum, 108, 219-227.
[25] Schmitt, M., Duerkop, A., & Marconcini, M. (2019). Earth observation image classification with 2D convolutional neural networks: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 162, 264-282.
[26] Rudin, C. (2019). Stop explaining black box machine learning models for high stakes decisions and use interpretable models instead. Nature Machine Intelligence, 1(5), 206-215.
[27] Li, X., Wang, Y., & Aloi, D. (2017). A review of spatial–temporal network data models. Data Science and Engineering, 2(2), 63-86.
[28] Rolnick, D., Donti, P. L., Kaack, L. H., Kochanski, K., Lacoste, A., Sankaran, K., ... & Irving, D. (2019). Tackling climate change with machine learning. arXiv preprint arXiv:1906.05433.
[29] Nguyen, Q., Chen, J., & Wei, K. (2018). Estimation of forest aboveground biomass using random forest and remote sensing data. Forests, 9(8), 482.
[30] Rodríguez-Galiano, V. F., Ghimire, B., Rogan, J., Chica-Olmo, M., & Rigol-Sánchez, J. P. (2012). An assessment of the effectiveness of a random forest classifier for land-cover classification. ISPRS Journal of Photogrammetry and Remote Sensing, 67, 93-104.
[31] Xu, Z., Zhang, Z., & Huang, H. (2016). Critical thresholds for farmland loss in the Pearl River Delta, China: Implications for spatial planning and management. Land Use Policy, 54, 535-546.
[32] Mandanici, E., & Bitelli, G. (2011). Comparison of different methodologies for updating a topographic database by using lidar data. ISPRS Journal of Photogrammetry and Remote Sensing, 66(3), 377-392.

THE REAL PURPOSE OF THIS REVIEW

The real purpose of this paper was not to give a review of AI applications in geodesy and geoinformatic, but it was to present new challenges that the academic community face in the time when open-source AI takes away jobs from traditional workers – the real people. The title of the paper is chosen so it can be interpreted in different ways. First, it is exactly what it says – a review paper on the current state of using AI in geodesy and geoinformatics. On the other hand, it is a review of AI itself, in this concrete example of NLP AI *ChatGPT*. We wanted to quickly check its capabilities in writing a research paper.

In this chapter the author will give personal opinions based on the above-written paper, previous work with *ChatGPT* and various materials (papers, articles, forum threads) read about this topic. Due to these factors, the following text might sound unscientific but that is intentional because the goal is for the reader to get the sense of how the author (who is not an expert on open source AI) feels about "openai" project called *ChatGPT* in the domain of writing scientific research.

First, let's focus on the paper *ChatGPT* wrote. The structure of the paper is good, it covers all aspects of a research paper. *ChatGPT* proposed a few more chapters like „Artificial intelligence: concepts and techniques", and „Case studies and examples", but those chapters were excluded due to the size of the paper. Would a real person structure a review paper like this? Maybe, but

probably this type of paper would include a chapter like „State of the Art “, and maybe some more historical context would be given. By giving instructions to *ChatGPT* this could be easily done but we wanted to let it structure the paper on itself as much as possible.

The language used in the text is quite sophisticated. It resembles the writing style of someone who is an accomplished novelist and also has a master's degree in geosciences. That is not the language that a traditional surveyor who spends days with a tripod and total station would use even while writing a research paper. Phrases such as „burgeoning synergy“, or „the marriage of AI and geodesy“ are probably not in the vocabulary of an average researcher.

It was instructed the AI to use references in the text and the AI did that. What is symptomatic is that *ChatGPT* always uses the same style of referencing – the reference is at the end of the paragraph. There is always only one reference for the written paragraph and names of the authors were never mentioned. This is not how an average human researcher would write the text, we usually want to mix things a little bit. Sometimes we start the sentence with the author’s names(s) and year when the paper was published, sometimes we use multiple sources for one statement, etc. These types of referencing were never used by the AI in this paper. This could be useful information since this could be a sign that some paper is not the work of the author who signed it but it was written by the AI.

Since the referencing is the soft spot of the *ChatGPT* the references used in this paper were checked by using Google Scholar and traditional search engines like Google and Bing. For most of the accurately cited papers, we could only get the title and abstract because the full text was protected by the paywall. Let us check the references that *ChatGPT* provided for us in this paper:

[1] – the paper with the exact title could not be found, one of the authors is renowned scientist and when visiting his Scholar page the paper could not be found on the list, the journal from the reference is real.
[2] – the paper with exact title could not be found, authors are well known scientists, the journal is real.
[3] – the paper with exact title could not be found, authors are well known scientists, the journal is real.
[4] – one of the authors listed is well known and often cited but the other two authors could not be found at all, journal exists but the paper with cited title could not be found.
[5] – the reference is correct.
[6] - the reference is correct.
[7] - the reference is correct.
[8] - the paper with exact title could not be found, authors are well known scientists, the book is real.
[9] - the reference is correct.
[10] – the author’s are found but could not be connected with the paper listed by AI.
[11] – the authors and the journal are real but the paper with the exact title could not be found.
[12] - the authors and the journal are real but the paper with the exact title could not be found.
[13] – the paper with the exact title was found, the authors are real scientists and the journal exists, but the author’s and journal do not match with the title of the paper.
[14] - the authors and the journal are real but the paper with the exact title could not be found.

[15] - the authors and the journal are real but the paper with the exact title could not be found.
[16] - the paper with the exact title was found, the authors are real scientists and the journal exists, but nothing matches (authors – paper title, paper title – journal, publishing year is wrong).
[17] – the reference is correct.
[18] - the authors and the journal are real but the paper with the exact title could not be found.
[19] - the reference is correct, *ChatGPT* even gave the URL for the reference (e-book).
[20] - the authors and the journal are real but they do not match, year of publishing is wrong.
[21] - the reference is correct.
[22] - the reference is correct.
[23] - the reference is correct.
[24] - the authors and the journal are real but the paper with the exact title could not be found.
[25] - the authors and the journal are real but the paper with the exact title could not be found.
[26] - the reference is correct.
[27] - the authors and the journal are real but the paper with the exact title could not be found.
[28] - the reference is correct.
[29] – the authors are real scientists, there is a paper with a very similar name but they do not match.
[30] - the reference is correct.
[31] - the authors and the journal are real but the paper with the exact title could not be found.
[32] - the authors and the journal are real but the paper with the exact title could not be found.

This simple analysis confirmed the statements of many other *ChatGPT* users that AI citing is hit and miss. Some references are correct, but AI often give non-existent reference. When reading the reference it sounds well, the title makes sense, the authors are real scientists and the journal or book is real, but when checked in detail it is often an imaginary paper. *ChatGPT* combines real ingredients and gives us something that does not exist. This is especially dangerous in academic work where the references are something of the most importance.

If you confront *ChatGPT* about bad referencing it becomes apologetic and gives excuses like: “I apologize for any confusion, but it appears there was a mistake in referencing.”, “The reference you provided does not exist in my knowledge base.”, “I apologize for the error. If you need assistance with any other references or information, please feel free to ask.”, “I apologize for any confusion. It seems there was an error in the citation.”, and sometimes, AI gives suggestions like: “I encourage you to verify information obtained through my responses and seek credible sources to support your arguments. Thank you for bringing this to my attention.” The wrong referencing provided by the AI is called “artificial hallucination” and it happens sometimes when AI gets its knowledge from unsupervised learning. To avoid “artificial hallucination” AI learning should be from supervised learning or there should be human evaluation of AI in case of unsupervised learning.

Based on my current experience in working with Chat GPT it is a good tool for generating ideas, creating scenarios, and especially for improving your writing. By giving simple instructions *ChatGPT* can create very imaginative scenarios, provide good ideas to solve a problem, suggest different methods when asked about specific problem that needs to be solved, or make already written text better by making it sound more scientific or professional. You should not use it to write a scientific paper or essay which includes references. Do not ask *ChatGPT* to predict your

course of Bitcoin because it does not know the future. One additional interesting thing about *ChatGPT* is that it has issues with simple math. The example below shows how *ChatGPT* deals with simple addition and multiplication (*ChatGPT* August 3 Version):

Using the weighted criteria and the scores, the overall scores for each plan are calculated:

- Plan A: (0.4 * 0.2) + (0.3 * 0.6) + (0.3 * 0.4) = 0.24
- Plan B: (0.4 * 0.6) + (0.3 * 0.4) + (0.3 * 0.7) = 0.49
- Plan C: (0.4 * 0.8) + (0.3 * 0.3) + (0.3 * 0.6) = 0.51

One of the problems that the academic community has faced since it's beginnings is plagiarism. How do we handle this issue is one of the current questions that the academic community has to solve. If we let AI write a paper and we only copy it, is it plagiarism or that's only a person using a tool as a help in writing a paper? What if we combine our text and AI's text? What about using AI to improve our text? It is certainly not OK for someone just to ask AI a couple of questions, copy the answers, merge it into one whole, and then present it like an original paper. But also, we must admit that it is a powerful tool and it would be a waste to not utilize it in some capacity. The question is where do we draw the line – what's allowed and what not if we want to present something as our original work? Some cases are simple, for example: AI-generated text and not edited by human in any capacity cannot be original work. But what if we let AI define the project, then we write it and then use AI to improve our text? These are the questions that should be answered as soon as possible in combination with improving tools for detection of AI written text.

There are some programs that inspect the text if it was written by AI or not. We have *GPTZero* and *TurnItIn* but these programs have issues with fake positive results. Practically speaking it is impossible to create a program that will be 100% accurate, there will be always cases of fake positives and fake negatives. As a writer, the best thing you can do is to avoid using AI in any capacity when writing your research paper.

Just like any existing tool, *ChatGPT* can be utilized well if used correctly but also it can cause more damage than benefit if used incorrectly. You could use a hammer to build a house, but also you could smash your fingers if you are not careful or if you use it incorrectly. Dear reader, I hope you could find something useful in this review that could help you in your future work with NLP AI.

Note: Even some parts of the introduction of this article were written by AI. Could you spot those parts?

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