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Utilization of GeoAI Applications in the Health Sector: A Review

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Abstract

This research describes the use of GeoAI, a geospatial data-based artificial intelligence, to improve the understanding and management of health in a global context. GeoAI enables the integration of geographic data such as maps, satellite images, and environmental information with artificial intelligence technology to analyze disease spread, health risk factors, and health resource management more accurately. This research uses a descriptive qualitative approach. The type of research used is a literature study. The literature review database used is by searching on Google Scholar, Scopus, and Google Book. The results of this study show that the basic concept of GeoAI involves more accurate spatial analysis, disease spread monitoring, disease outbreak prediction, and more efficient health resource management. However, challenges such as access to adequate data, lack of understanding among health professionals, and data privacy and security issues need to be addressed for GeoAI to be effectively implemented. In conclusion, GeoAI has great potential in improving public health and addressing global health challenges, but requires careful steps in its implementation.

Keywords: GeoAI, GIS, Geography, Public health.

Introduction

Healthcare is one of the crucial aspects of human life that continues to evolve over time. Advances in information and communication technology have opened up exciting new opportunities in improving the quality of healthcare services. One of the latest promising innovations is the use of geospatial-based artificial intelligence, or GeoAI, which combines geographic data and artificial intelligence (Kamel Boulos et al., 2019). In this context, research on the utilization of GeoAI applications in healthcare is becoming increasingly important. The utilization of GeoAI in health allows combining geographic data, such as maps, satellite images, weather data, and other environmental data with artificial intelligence technologies for a better understanding of health issues (Amjad et al., 2023). For example, GeoAI can help in monitoring the spread of infectious diseases, predicting disease incidence, mapping health resources, and understanding health behavior patterns based on location (Kaur et al., 2021).

The use of GeoAI in health has generated rapidly growing interest as it has tremendous potential in changing the way we understand, diagnose, and respond to health issues (Tagde et al., 2021). In this context, research and applications of GeoAI in various health areas such as infectious disease monitoring, health risk factor analysis, public health crisis management, and health resource mapping have grown rapidly. However, in an effort to explore the potential of GeoAI in improving public health, several challenges need to be considered and overcome. First, limited access to quality and relevant geospatial data is often a major challenge in many regions (Dicuonzo et al., 2021). Data such as satellite imagery, geographic maps and environmental data are not always freely available or easily accessible, especially in developing countries (Manakane et al., 2023). Limited data availability can limit the ability to develop effective GeoAI applications in healthcare (Kamel Boulos et al., 2019).

According to Janowicz et al. (2022), geospatial data has a large volume and high complexity, which requires significant computing resources and technical expertise that may not always be available in a healthcare environment. Adequate infrastructure and the use of sophisticated AI algorithms are required to cope with this data (Tagde et al., 2021). Furthermore, privacy and data security issues are crucial considerations in the use of personal health data and geospatial data (Mullachery & Alismail, 2023). The use of these data raises sensitive issues related to individual privacy, and it is important to ensure that these data are closely guarded to protect privacy while enabling the necessary GeoAI analysis.

Limited financial resources are also an obstacle that needs to be taken into account in the development and implementation of GeoAI applications in healthcare (Istepanian & Al-Anzi, 2018). Health organizations and government agencies may have to allocate additional budgets to adopt these technologies, which can be a barrier in resource-constrained regions (Kamel Boulos & Al-Shorbaji, 2014). Finally, a lack of awareness and training among health professionals and medical personnel may mean that they do not fully understand the potential of GeoAI or how to use it effectively in their health practices (Del Mastro et al., 2020). Training and awareness raising are needed to maximize the benefits of GeoAI in the healthcare context.

In order to overcome these challenges and understand how GeoAI can provide maximum benefit in improving public health, more in-depth research and collaboration between healthcare professionals, data scientists, and artificial intelligence experts is crucial. As such, this article aims to provide a comprehensive overview of GeoAI utilization in healthcare and highlight the importance of understanding and overcoming the barriers that may arise in adopting this technology.

Literature Review

GeoAI is a combination of geospatial data and artificial intelligence (AI), which has great potential in improving our understanding of health issues (Chauhan & Shekhar, 2021). The basic concept of GeoAI involves collecting geographic data such as maps, satellite images, and weather data, which are then analyzed by AI algorithms to identify health-related patterns, relationships, and trends (Mesko, 2017). This enables monitoring of disease spread, analysis of health risk factors, management of health resources, and better understanding of environmental health (Amjad et al., 2023). Disease spread mapping is an important aspect in epidemiology and public health. With GeoAI, mapping the spread of disease becomes more accurate and efficient (Pertuak et al., 2023). Geographic data is used to visualize disease spread in high detail, identify high-risk areas, and predict potential outbreaks (Rakuasa et al., 2021). Through this mapping, faster action can be taken in controlling diseases and planning better public health responses (Nuraini et al., 2021). By combining the concepts of GeoAI and disease mapping, this research seeks to uncover the great potential in improving healthcare services and understanding public health in general.

Research Method

This research uses a descriptive qualitative approach. Qualitative research is a research procedure with descriptive data results in the form of written or spoken words (Hamilton & Finley, 2019). Qualitative research aims to analyze the quality of a study. The type of research used is a literature study which is research that has been done before by collecting books, journals, magazines, and scientific papers that are interrelated with the research problems and objectives. Literature study is a data collection technique carried out by conducting a study of books or literature related to the problem being solved (Roller, 2019). The literature review database used is by searching on Google Scholar, Scopus, and Google Book. The search was conducted using the keywords GeoAI, GIS, Geography, Public health.

Results and Discussion

1. Basic Concepts of GeoAI in Healthcare

Definition of GeoAI

GeoAI, which stands for Geographic Artificial Intelligence, is a field concerned with the use of artificial intelligence (AI) to understand, analyze, and manage geographic or spatial data (Muin & Rakuasa, 2023). This geographic data includes information that has a location component or geographic coordinates, such as maps, satellite images, GPS data, and more (Kurniadi et al., 2019). GeoAI combines elements of AI, such as machine learning, deep learning, and data analytics, with geospatial science to produce deeper understanding and accurate predictions of real-world phenomena. One of the main applications of GeoAI is in environmental mapping and monitoring. Using machine learning techniques, GeoAI can process satellite image data to detect changes in land cover, pollution, deforestation, or even natural disasters such as floods and earthquakes (Rakuasa & Latue, 2023). This allows organizations and governments to take faster action in addressing environmental issues.

In addition, GeoAI also has a significant role in urban planning and natural resource management (Manakane et al., 2023). By combining geographic data with sophisticated data analysis, GeoAI can help in planning transportation, water distribution, and land management more efficiently (Rakuasa et al., 2023). It also helps in identifying optimal locations for new infrastructure or development projects. In addition, GeoAI is also applied in socio-economic monitoring and analysis. For example, it can be used to understand population mobility, consumption patterns, and the economic impact of changes within a given region. Overall, GeoAI is an important field in understanding our world better, making more informed decisions, and addressing the many environmental, social, and economic challenges we face.

The Role of Geographic Data in Health

Geographic data has a very important role in the field of health. This is because spatial information can provide deep insights into a number of health issues, aiding better planning, monitoring and decision-making in the healthcare system (Muin & Rakuasa, 2023). One of the main roles of geographic data in health is disease mapping and epidemiology (Kamel Boulos & Le Blond, 2016). Geographic data allows researchers and health practitioners to track the spread of diseases, identify epidemic hotspots, and understand disease transmission patterns in different regions (McAllister et al., 2017). This information is invaluable in controlling outbreaks, planning vaccinations, and allocating health resources efficiently. In addition, geographic data is also used in health service planning. Spatial analysis can help identify areas that may have limited access to health care facilities, such as hospitals or health centers (Muin & Rakuasa, 2023). This allows planning for the location of new health facilities or improvements to existing infrastructure to ensure that the population has equal access to quality health care (Latue et al., 2023).

Geographic data also helps in public health research. By analyzing geographic data, researchers can identify environmental factors that may contribute to public health, such as air pollution, water quality, or access to fresh food. This helps in designing more effective intervention programs to improve people's well-being (Latue et al., 2023). Finally, geographic data also plays a role in individualized patient care. Geographic health information systems can provide doctors with quick access to a patient's medical history and related geographic data, such as the location of residence and surrounding neighborhood. This assists doctors in making better diagnoses and planning treatments that suit the patient's condition and environment. Overall, geographic data has a very important role to play in understanding, preventing and addressing health issues at various levels, from the individual to the population level.

Relevance of GeoAI in Disease Understanding

The relevance of GeoAI (Geographic Artificial Intelligence) in disease understanding is significant as it helps integrate geographic data and artificial intelligence to better understand how diseases spread and interact with specific environmental factors (Davis & Shanley, 2017). One of the main roles of GeoAI in disease understanding is infectious disease mapping and monitoring. By utilizing satellite image processing techniques and spatial data analysis, GeoAI can assist in mapping areas with a high risk of transmission of certain diseases such as malaria, dengue fever, or other infectious diseases. This enables more effective planning of health interventions and appropriate deployment of resources. In addition, GeoAI also helps in the understanding of environment-related disease risk factors. By analyzing geographic data, GeoAI can identify environmental factors such as air pollution, water quality, population density, and access to health services that may contribute to certain diseases (Amjad et al., 2023). This helps in designing more appropriate and efficient prevention strategies, as well as informing environmental policies that can minimize disease risk.

GeoAI also enables real-time epidemiological monitoring (Topol, 2019). By combining geographic data and health data, GeoAI can generate a more accurate understanding of the spread of disease over time (Bellinger et al., 2017). This allows governments and health agencies to take swift action in controlling outbreaks and organizing efficient health responses. Finally, GeoAI can also help in healthcare system planning. By analyzing geographic data on the location of health facilities, population served, and accessibility, GeoAI can assist in planning a more equitable distribution of health facilities, thereby improving people's access to necessary health services. Overall, GeoAI is an important tool in disease understanding, helping communities and governments to address health challenges more effectively.

2. Disease Distribution Mapping

Epidemiologic Mapping

Epidemiologic mapping is the process of identifying, recording, analyzing, and understanding the spread and distribution of disease in a population and the factors that influence it (Bellinger et al., 2017). It utilizes the principles of epidemiological science and spatial or geographic data to produce a visual representation and deeper analysis of how diseases spread across different geographic areas. Epidemiological mapping can assist in planning, monitoring and evaluating disease prevention and control efforts. One important aspect of epidemiologic mapping is the creation of disease maps (Oliveira et al., 2013). These maps are used to identify disease hotspots, spread patterns, and areas that may have a high risk of developing a particular disease. As such, these maps assist governments and health organizations in efficiently allocating resources to address public health issues. For example, in the case of an infectious disease outbreak, epidemiological mapping can help in planning vaccination or quarantine campaigns.

Epidemiological mapping also helps in the identification of environmentally related disease risk factors (Mohr et al., 2017). By analyzing spatial data, such as water quality, air pollution, or population density, epidemiological mapping can reveal the relationship between these factors and the spread of certain diseases (Vrijheid, 2014). This information helps in designing more appropriate prevention strategies, including environmental interventions that can reduce disease risk. Finally, epidemiological mapping enables real-time epidemiological monitoring. By utilizing the latest technology and data, epidemiological mapping can provide rapid and accurate information on the spread of disease in the population (VoPham et al., 2018). This is invaluable in controlling disease outbreaks and responding quickly and efficiently to emergency health situations. Overall, epidemiologic mapping is an important tool in the science of epidemiology that helps in the understanding, prevention, and control of diseases in human populations.

Disease Outbreak and Event Prediction

Disease outbreak and incidence prediction is an attempt to anticipate, analyze, and forecast the future spread of disease. This is an important aspect of public health and epidemiology, as it can help governments, health organizations, and communities to take more effective preventive measures (Kjellstrom et al., 2016). One of the tools used in these predictions are epidemiological models, which utilize historical data, disease parameters, and environmental factors to generate projections of how diseases will spread in the population (DeVerteuil, 2015). Epidemiological models are used to forecast various aspects of an outbreak, such as the number of new cases, rate of spread, and possible health and economic impacts. This allows governments and health organizations to plan resource allocation, such as vaccination or treatment, better and more efficiently (Rusdi et al., 2022). In addition, epidemiological models can also help in identifying areas that may have a high risk of developing certain diseases, so that preventive measures can be aimed more precisely.

In the modern era, information technology and artificial intelligence (AI) are increasingly becoming an important part of disease outbreak and incidence prediction. Big data such as public health data, geographic data, and travel data can be used to train AI models that can predict the spread of diseases more accurately. For example, analysis of social media data can provide insights into disease symptoms and population mobility that can be used in prediction models. These technologies enable governments and health organizations to respond to outbreaks faster and more efficiently (P. S. Chauhan & Shekhar, 2021). It is important to note that predicting disease outbreaks and events is not easy and always has a degree of uncertainty. However, with the use of modern techniques, such as epidemiological models and AI, and international cooperation in data and information exchange, we can minimize the impact of severe disease outbreaks and help protect public health more effectively. Accurate predictions can be an invaluable tool in dealing with global health challenges.

Case Study: Mapping the Spread of Infectious Diseases in Indonesia

The case study of mapping the spread of infectious diseases in Indonesia is a concrete example of how geographic and epidemiological data analysis can be used to understand and address public health issues. For example, in situations such as the COVID-19 pandemic, mapping can provide insights into how the virus spreads from one region to another, assisting governments in decision-making related to controlling the spread of the disease (Jumadi et al., 2022). Mapping can pinpoint areas with a high risk of transmission, enabling efficient allocation of health resources and appropriate quarantine or lockdown planning (Rejeki et al., 2022). In addition, mapping can also assist in locating sources of infection and disease transmission chains. By tracking disease cases and linking them to the geographic location of patients, researchers and health workers can quickly identify critical points where disease transmission occurs. This information enables more careful preventive measures, such as temporary closure of infected areas or more accurate contact tracing (Surendra et al., 2023).

Furthermore, mapping can also help with vaccine and drug distribution planning. By mapping population, health infrastructure, and demographic data, governments can plan more effective resource allocation to vaccinate communities. This is an important aspect of tackling a pandemic like COVID-19, where mass vaccination is a top priority. Finally, mapping the spread of infectious diseases in Indonesia can also provide insight into how environmental factors such as population density, water quality and air pollution can affect the spread of disease. By understanding these factors, governments and health organizations can take steps to reduce the risk of disease spread in vulnerable areas. In conclusion, the case study of mapping the spread of infectious diseases in Indonesia is a clear example of how geographic and epidemiological data can be used to address complex and far-reaching public health challenges.

3. Use of GeoAI in Global Health

Global Health Monitoring

Global health monitoring is a systematic effort to supervise and monitor the health status of people around the world (Misslin et al., 2016). This is done with the aim of identifying, analyzing, and controlling infectious and non-communicable diseases that can spread across countries and have a global impact (Kurniawan et al., 2023). Global health monitoring involves various international organizations, governments, health institutions, and researchers to collect, analyze, and share health data continuously. In the modern era, information and communication technology plays an important role in improving the efficiency of global health monitoring, enabling the rapid and effective exchange of health data and information. One important component of global health monitoring is epidemiological monitoring. This involves collecting and analyzing data related to infectious diseases such as new viral outbreaks, as well as the spread of existing infectious diseases such as malaria, HIV/AIDS, and tuberculosis (Ismail et al., 2020). This information is used to understand how infectious diseases spread, identify epidemic hotspots, and plan appropriate public health responses. In addition, global health monitoring also includes monitoring non-communicable diseases such as diabetes, heart disease, and cancer, as well as risk factors such as lifestyle and environment (Sambodo et al., 2021).

Global health monitoring serves as an early warning system that can alert the international community of potential disease outbreaks that can spread rapidly across national borders (Rahmanti et al., 2012). It enables rapid prevention and control measures and international coordination in response to emergent disease outbreaks. In addition, global health monitoring enables evaluation of the impact of global health interventions such as vaccination programs, treatment, and broader public health campaigns (Rejeki et al., 2022). It is important to note that international collaboration in global health monitoring is essential. Organizations such as the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) play a central role in coordinating these efforts. Openly collected and shared health data also enables broader scientific research and accelerates the development of knowledge about diseases and their management. Global health monitoring is a critical tool in keeping people around the world healthy and minimizing the impact of potentially harmful disease outbreaks.

4. The Future of GeoAI in Healthcare

Future Trends

The future of GeoAI in healthcare promises major breakthroughs in various aspects of healthcare (Kamel Boulos et al., 2019). First, we can anticipate that GeoAI will become increasingly important in disease monitoring and prediction. These technologies will continue to utilize geospatial data to better understand population movements, environmental factors, and patterns of disease spread. This will enable health systems to respond to disease outbreaks more quickly and effectively, and enable more in-depth epidemiological research (Mullachery & Alismail, 2023). In addition, GeoAI will be key in better health planning. With more advanced geospatial data analysis, GeoAI will help in determining the optimal locations for health facilities, such as hospitals and health centers. This will improve the accessibility of health services, especially for populations located in remote or hard-to-reach areas (Kaur et al., 2021).

Furthermore, GeoAI will also play an important role in the development of more personalized healthcare. Clinicians will be able to utilize geospatial data to better understand the environmental factors that affect their patients' health. This will allow healthcare providers to design more appropriate and effective treatments, taking into account the environment around the patient (P. S. Chauhan & Shekhar, 2021). Overall, the future of GeoAI in healthcare will open up various opportunities to improve the understanding, prevention and treatment of diseases. With the development of technology and increased access to geospatial data, we can expect GeoAI to serve as an invaluable tool in achieving better public health and more efficient and personalized healthcare.

Potential of GeoAI Technology Development

The potential development of GeoAI (Artificial Intelligence based on geospatial data) technology in the health sector is very promising and has a significant positive impact. First, GeoAI can be used for disease monitoring and prediction. By utilizing geospatial data such as patient location, population movement patterns, and environmental factors, GeoAI can help in detecting and forecasting the spread of diseases more accurately (Janowicz et al., 2022). This is particularly important in the face of infectious disease outbreaks such as pandemics, enabling a faster and more effective response. Secondly, GeoAI also supports better planning of health facilities. With geospatial data analysis, GeoAI can assist governments and health agencies in determining the optimal locations to build hospitals, health centers, or other medical facilities (Mesko, 2017). This can improve the accessibility of health services for the community, especially in remote areas or those that require more emergency health care.

Furthermore, GeoAI can be used in environmental and air quality monitoring. Air pollution and other environmental factors can have a negative impact on human health. GeoAI enables more accurate and real-time monitoring of air quality and the environment in various locations, allowing for more appropriate actions to be taken to protect public health. Finally, GeoAI can enable the development of more personalized healthcare. By understanding the geographical and environmental factors that affect an individual's health, GeoAI can help doctors design treatments that are better suited to a patient's needs. This enables a more holistic approach to healthcare and increases the opportunity for disease prevention. The use of GeoAI in healthcare is a clear example of how geospatial technology and data can be used to improve our understanding of public health, enable more effective responses to health problems, and design better, personalized treatments. By continuing to develop and utilize GeoAI, we can expect greater progress in the health sector that will benefit many people.

Conclusion

The conclusions of this study underscore the great potential that GeoAI has in improving the understanding and management of health worldwide. The merging of artificial intelligence (AI) technology with geospatial data has opened the door to a wide range of applications that can change the way we approach health issues. In the context of health, GeoAI provides the ability for more accurate disease monitoring, analysis of health risk factors, more efficient management of health resources, and a better understanding of environmental health. The importance of mapping the spread of disease using GeoAI becomes very clear. The ability to track and understand spatial and temporal patterns of disease spread is an invaluable tool in responding to infectious disease outbreaks and taking better preventive measures. GeoAI also enables prediction of potential future disease spread, allowing authorities to plan and allocate resources more efficiently. However, this research also reflects the challenges that need to be overcome in the utilization of GeoAI in the health sector. One of these is access to quality and relevant geospatial data, which is not always available in all regions. There is also a lack of understanding and training among medical and health professionals about GeoAI. In addition, the importance of maintaining data privacy and security in the use of GeoAI in healthcare must be prioritized. Overall, this study highlights the potential of GeoAI to provide significant benefits in efforts to improve the quality of healthcare services and understanding of public health in general. By understanding the basic concepts of GeoAI and addressing the challenges, we can more effectively utilize this technology to support public health and better meet global health challenges. GeoAI is a powerful tool in our arsenal to achieve these goals in the future.

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