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THE USE OF ARTIFICIAL INTELLIGENCE IN ANALYZING HISTORICAL DEMOGRAPHIC DATA

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ABSTRACT

This paper aims to highlight the most significant artificial intelligence technologies and tools employed in processing historical demographic data, and explores the primary challenges that arise after their implementation. Advanced AI technologies have revolutionized the analysis of historical demographic data and the prediction of future trends, what enhances our understanding of the past and addresses gaps in historical records. Nevertheless, several challenges emerge, including the accuracy of historical events that involve demographic, social, cultural, and economic aspects of populations and the various phases they have experienced, such as data distortion, bias, and ethical issues. These challenges may undermine the credibility of information for current or future generations and lead to decisions and predictions with substantial implications for social, health, and economic policies.

KEYWORDS

Data, Population, Historical Era, Artificial Intelligence, Challenges

CITATION

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Introduction.

Historical demographic data is an invaluable resource for understanding significant developments and changes that various peoples and civilizations have experienced over time. This data includes information on demographic characteristics and phenomena, and also touches on the social and cultural aspects of individuals. Demographic researchers and historians face significant challenges in gathering this data and ensuring its accuracy and precision.

With the advancements in modern technology, particularly the integration of artificial intelligence into scientific research and studies, AI has become essential in analyzing historical demographic data thanks to its advanced capabilities. This analysis is conducted through AI algorithms and models that enable machines to learn from data, understand developments, analyze them, and extract difficult-to-detect information using traditional statistical methods; thus; improving the accuracy of future predictions.

Moreover, the challenges encountered in analyzing data using artificial intelligence techniques are multifaceted, including the quality of processed historical demographic data and its accuracy in future predictions.

From this context, the main question of the study is as follows: “What are the prominent AI technologies and tools used in analyzing historical demographic data?”. The sub-questions include:

- What are the main traditional sources of historical demographic data, and how are they analyzed?
- How do these sources compare to AI technologies and tools?
- What are the ethical challenges and privacy issues associated with using AI in analyzing demographic data?

Main Objectives:

The study aims to:

- Identify the key technologies and tools of artificial intelligence used in processing historical demographic data.
- Determine the major challenges faced by historical demographic data in the context of AI use.

Study Significance

The exploration of artificial intelligence in the analysis of historical demographic data is paramount, considering the qualitative advancements in scientific research and demographic studies. This area has attracted widespread interest from researchers across various disciplines, notably demographers and historians.

This study will delve into the impact of transitioning from traditional to advanced methodologies, highlighting substantial challenges related to the negatives of AI, including concerns about the quality and accuracy of data utilized in these analyses.

Study Methodology

The methodology for analyzing the topic of this study incorporates two primary approaches:

- Firstly, the descriptive method, as defined by Mohamed Abdel Salam, is a foundational element in scientific research and represents one of the systematic forms of scientific analysis and interpretation. It is employed to quantitatively describe a specific phenomenon or problem by collecting, classifying, analyzing, and subjecting data and information to rigorous study (Mohamed. A., 2020).
- Secondly, the historical method is described as a research approach that seeks to discover and interpret historical facts through the analysis and synthesis of past events documented in historical records, after ensuring the accuracy of this information and providing scientific interpretations and predictions in the form of relatively general and stable laws (Collective Book, 2019, p. 123). Additionally, Maliha Basal defines it as a set of methods and techniques used by historians to ascertain historical truths and reconstruct the past in its entirety, as it existed in its original time and place. These methods continuously evolve and integrate within the broader spectrum of human knowledge (Maliha. B., 2022, p. 15). These definitions underscore that the historical method is crucial for research and studies pertaining to ancient times. Within this framework, data sources must be meticulously verified for accuracy and reliability to contribute to a comprehensive understanding of historical changes and developments and facilitate planning and future forecasting.

Concepts of the Topic

First Concept: Historical Demographic Data

This term integrates two concepts: 'demographic data,' which refers to numerical or digital information related to population statistics (Multidisciplinary Demographic Dictionary, p. 31), and 'historical,' which pertains to the ancient time during which this demographic data is scrutinized. This conceptual framework sets the stage for a detailed examination of how populations have evolved over time, and of the implications of these changes.

Second Concept: Artificial Intelligence

Artificial intelligence is encapsulated by two terms: 'intelligence', which denotes the ability to understand, process, and think critically, and 'artificial', signifying something created or synthetic. The concept of 'artificial intelligence' was initially defined by John McCarthy in 1955 to get machines with intelligent behavior (Saleh. A., 2022, p. 372).

The origins of the term date back to 1950 when the eminent scientist Alan Turing introduced the Turing Test, which assesses a computer's intelligence and its ability to mimic the human mind. Subsequently, Anthony Oettinger, at the University of Cambridge, devised an experiment to simulate a human shopping process, which marked the inaugural successful experiment in what is now recognized as machine learning (Magdi Salah Taha. A., p. 106).

Artificial intelligence is part of computer science that develops intelligent machines capable of mimicking human brain interactions and includes a set of programs and applications for processing data and solving intricate time-intensive problems using diverse patterns or models (Saad Hassan Mohey El-Din Abdel Wahab, October 2023, p. 712). Artificial intelligence is bifurcated into two primary branches based on data set models and specified objectives:

1. **Predictive Artificial Intelligence or Predictive Learning for AI**:

This branch utilizes intelligence and computer algorithms to forecast future outcomes by analyzing historical data from small to medium-sized data sets. It makes predictions by analyzing historical data through probabilities and statistical modeling, encompassing "artificial intelligence learning," "machine learning," "deep learning," "cognitive learning," and other related technologies (Jorge Garza Oloa, 2024, p.492).

2. **Generative Artificial Intelligence or Generative AI Creation**:

This branch employs large language models (LLMs), known as computer algorithms, and data sets to create new content such as texts, images, videos, coding, and more. It learns from a large, primarily unclassified, quantitative data set to generate new data based on similarities in the training data, and predicts the next values using statistical operations (Jorge Garza Oloa, op.cit. p.493).

3. **Historical Demographic Data: Sources and Challenges**

Historical demography stands as a pivotal branch of demography, focusing on the study of populations in historical contexts. It examines population dynamics in terms of movements, crises, diseases, epidemics, famines, and their outcomes, along with aspects of marriage, inheritance, production, trade systems, and other political, economic, and social events that have influenced population size, composition, and distribution. This branch also covers vital statistics such as births, marriages, and deaths (Rachedi. K., 2018, p. 21).

The sources of demographic data in historical demography pose substantial challenges for demographers and historians due to issues of inaccuracy and limited availability of information. For instance, studies concerning ancient European populations often depend on external sources that were not originally intended for scientific purposes, including church records, tax lists, marriage contracts, and funerary inscriptions.

These sources frequently show numerous shortcomings due to gaps, poor preservation, or loss resulting from conflicts (Mohammed. H., 2014, p.15). Furthermore, demographic records predominantly documented events related to Catholics, excluding Protestants, and lacked information on children who were not baptized, among other limitations faced by researchers when utilizing Parish Record.

In such scenarios, alternate estimates such as soldier and family numbers, or the usage of tax and hospital records, were employed, although they were challenging to study and analyze due to their non-statistical nature (Mohammed. H., op. cit. p.15).

Historical demography utilizes the demographic method to study populations and past demographic events. This field has embraced both quantitative and qualitative approaches due to the nature of these studies. Some of the key techniques employed include retrospective observations, longitudinal studies, and cross-sectional studies (Rachedi. K., op. cit. p. 21).

Louis Henry, a renowned French demographer and historian, is recognized as one of the pioneers of historical demography. He significantly advanced the field with the development of the "method Henry," a technique for family reconstitution. Henry gathered data on family histories using special forms, which captured details about family composition or spousal separation, marriages, births, and child deaths.

This collected data facilitated the comparison of dates to ascertain the ages of spouses at marriage, widowhood, or death, the duration of widowhood in cases of remarriage, and the age of the father or mother at each child's birth. These insights enabled the calculation of various demographic indicators such as fertility rates, age at marriage, reproductive output, and the interval between marriage and first birth (Mohammed H., op.cit. p. 15).

In 1956, Louis Henry, in collaboration with Michel Fleury, who specialized in document preservation, published "Manuel for Parish Record Analysis", which outlined a meticulous and precise methodology for demographic data analysis. The initial phase involved documenting baptism, marriage, and burial contracts, including names, surnames, ages, and information about children on cards or special forms.

The subsequent phase focused on family reconstruction over two generations on other cards, which facilitated the calculation of demographic rates such as age at marriage, age at death, duration of marriages, rates of legitimate and illegitimate births, intervals between successive births, remarriage rates, and widowhood durations (Mohammed. H., op.cit. p. 16).

Archaeology and artifacts represent vital resources for historical demography studies, particularly in analyzing different historical periods, including those marked by epidemics. For example, excavations in Métezeau, Dreux, France, uncovered non-traditional graves characterized by mass burials with two to twenty-two individuals. Initially believed to date to the twelfth century, recent radiocarbon dating has revised their dating to the fourteenth century, offering new insights into the demographic impacts of historical epidemics (Castex, D., &Cartron, I., 2007).

Additionally, since the early days of Islam, the Islamic state has maintained demographic records through the establishment of Diwans, which preserved data pertaining to state rights derived from various activities and finances, including detailed records on the military and workforce (Mohammed. H., op. cit. p. 10).

However, researchers studying medieval Islamic history encounter more difficulties with archival documents than their counterparts focusing on European history. To address these challenges, scholars have broadened their research methodologies, engaging in archaeological excavations in urban areas and applying critical and cautious interpretations of the demographic information available from Islamic sources, such as travelers' accounts, annals, biographies, and class records (Hisham. S., 2023, p. 55).

Through these efforts, historical demographic data sources have significantly advanced our understanding of the demographic characteristics of past populations, despite inherent shortcomings and inaccuracies linked to the original purposes of these recordings.

A. Examples of Using Artificial Intelligence Techniques in Analyzing Historical Demographic Data

First Study: Using Artificial Intelligence to Predict Iraq's Population Until 2030

Researchers in this study combined artificial intelligence techniques with traditional methods to forecast the future population of Iraq by 2030 (Ashour, Dahlan, et al., 2023, p. 17-21).

1. **The First Model: Autoregressive Integrated Moving Average (ARIMA)**

This statistical model is employed to analyze time series data and predict future values. ARIMA is versatile and adaptable to different types of time series data, what enhances its utility in demographic forecasts (Joshua Noble, 2024).

2. **The Second Model: Recurrent Neural Network (RNN)**

RNN stands out as a sophisticated method of artificial intelligence, mimicking the human brain’s pattern recognition capabilities. This model excels in learning from historical data, allowing it to optimize predictions based on accumulated experiences (Jamal Ahmed A., Abdel Wahab A., 2010, p. 579).

The findings from using the RNN model indicated that, despite the limited availability of historical demographic data, the application of AI significantly enhanced the accuracy of population projections for Iraq in 2023. These projections are instrumental in aiding policymakers craft strategies that align with sustainable development goals, including healthcare planning, educational resource estimation, infrastructure development, and enhancing population welfare sustainably.

Other Studies:

A notable application of AI in the realm of historical analysis is the neural network, named Ithaca, which was developed by researchers at Deep Mind and Ca' Foscari University of Venice. Ithaca has been instrumental in reconstructing missing segments of ancient inscriptions and in assigning accurate dates and origins to these texts.

This advancement is part of the broader scientific revolution initiated by artificial intelligence, which has significantly enhanced the processing of ancient data and facilitated a deeper understanding of the contexts within which ancient civilizations operated, including their cultural frameworks and thought processes (Cain, D., 2023).

Furthermore, a pivotal study, conducted by Professor Johannes Preiser-Kapeller of the Austrian Academy of Sciences, utilized network analysis software to elucidate connections within Byzantine church documents from the fourteenth century. This analytical approach did not only highlight previously obscured patterns of influence, but also showcased how the societal structure was intricately supported by the unrecognized contributions of women; thus, it revealed a hidden layer of historical social dynamics (Cain, D., 2023).

B. What is Next After Using Artificial Intelligence in Historical Demographic Studies?

The deployment of various artificial intelligence techniques and tools has resulted in a significant advancement in the analysis of historical demographic data and in the projection of future trends. This technological progress supports a more profound comprehension of historical contexts and helps filling the voids left by incomplete historical records.

Nonetheless, the integration of AI into historical studies raises critical questions about the authenticity and accuracy of reconstructing historical events. One must consider whether AI can adequately bridge the gaps in historical narratives in a way that closely mirrors reality. This issue is crucial in the light of the potential challenges and distortions that may arise, as illustrated by the discussions in recent scholarly work (Cain, D., 2023).

For instance, the Midjourney platform, an AI-driven tool, exemplifies these concerns with its capability to convert textual descriptions into vividly realistic images, crafting depictions of fictitious historical events, such as the "Blue Plague incident" in the Soviet Union and the "Tsunami of 2001". Such representations, while artistically compelling, raise significant risks to historical understanding by potentially introducing falsehoods into the academic discourse and undermining trust in historical documentation and interpretation. (Cain, D., 2023)

Conclusions

Artificial intelligence is one of the most significant advancements that contributed to the giant leap in practical studies; its integration has become necessary for many advantages. Techniques like recurrent neural networks developed for future predictions and bridging gaps in many missing past data have enhanced understanding of many changes the world has experienced in historical periods. AI techniques also helped decipher and interpret ancient artifact inscriptions.

Analyzing historical demographic data does not only rely on statistical aspects, but also needs understanding events in their sequence with the impacts of various social, cultural, economic aspects, and more.

However, we still face challenges regarding ethics and unbias, and whether all generated texts and historical events are presented with accuracy and credibility.

In this context, Dr. Mohammed Ismail noted that "applying artificial intelligence to distant past helps draw links across a broader range of the historical record and corrects distortions that come from analyzing historical events through one document at a time. However, it introduces its own distortions, perhaps we take a slip towards bias or outright fabrication into the historical record and the historical facts that some Orientalists have done to distort the image of Islam and Muslims and diminish the merit of the Arab-Islamic civilization on Europe and the whole world."

In conclusion, artificial intelligence is merely a tool that requires human intelligence to control it because human wisdom and awareness are more capable than this tool. Past events affect the present and future. Besides, not controlling their authenticity will falsify truths for future generations (Mohammed. I, 2023).

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