ARTIFICIAL INTELLIGENCE IN SCIENCE, ARTS & COMMERCE:

AN APPLICATION BASED APPROACH

Dr. Dipak Kundu
Dr. Shipra Bhattacharjee
Dr. Surya Narayan Ray
Dr. Nilendu Chatterjee

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- **Chapter 7**, by Rupak Bhattacharyya, brings the focus to **mathematics**, unpacking the theoretical foundations that underpin AI and its cross-disciplinary implementations in modern sciences.
- **Chapter 8**, by Atanu Sengupta and Madhusree Mukherjee, shifts the lens to the **developing world**, asking a critical question: how does AI operate in societies with economic constraints? Their metaphor of "The King and the Pauper" highlights disparities in technological access and policy preparedness.

Part II: AI in Society and the Arts — Creativity, Ethics, and Knowledge Systems

This section explores the philosophical, aesthetic, and ethical questions that arise as AI enters the cultural and cognitive domains of human life.

- **Chapter 9**, by Dr. Avishek Naskar, juxtaposes **Emotional Intelligence and Artificial Intelligence** in the realm of public administration, offering insights into governance and empathy in automated systems.
- **Chapter 10**, by Rudra Bibhu Bhattacharyya, explores how AI informs **international relations and statecraft**, particularly through the lens of "deep state discourse" and technological dominance.
- **Chapters 11 and 12**, by Dr. Qaisur Rahman and Mr. Pratik Roy Gupta, focus on **AI in education and interdisciplinary research**, emphasizing its transformative potential in pedagogy and knowledge dissemination.
- **Chapter 13**, by Dr. Gargi Basu, continues the discussion on interdisciplinarity through **climate modelling**, showcasing how AI integrates environmental science and computational innovation.
- **Chapter 14**, by Kanai Sarkar, transitions into the **arts and education**, demonstrating how AI can foster creativity among undergraduate students and reshape art education curricula.
- **Chapter 15**, by Samirranjan Adhikari and Moumita Karmakar, draws from **Frankfurt School aesthetics** to critically examine AI's role in redefining artistic creativity—moving "from Frankfurt to function."

CHAPTER – 13

THE ROLE OF ARTIFICIAL INTELLIGENCE AND INTERDISCIPLINARY RESEARCH IN CLIMATE MODELING

Dr. Gargi Basu [1]

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Abstract

Emergence of Artificial Intelligence (AI) has transformed the manner of interdisciplinary scientific research. By employing machine learning algorithms and advanced data analytics, researchers can now synthesize knowledge from multiple disciplines, thereby gaining deeper insights and developing innovative solutions. This integration of AI has led to groundbreaking discoveries in fields such as bioinformatics, climate science, and materials engineering. Researchers can now process vast amounts of data from diverse sources, identifying patterns and correlations that were previously undetectable. As a result, AI-driven interdisciplinary research is accelerating the pace of scientific progress and opening new avenues for addressing complex global challenges.

This paper attempts to discuss how incorporation of AI in climate models has improved the predictive capacity of these models. AI-powered climate models have demonstrated enhanced accuracy in forecasting short-term weather patterns and long-term climate trends. These models leverage machine learning algorithms to process vast amounts of data from diverse sources, including satellite imagery, weather stations, and historical records. By identifying complex patterns and relationships within this data, AI-enhanced climate models can provide more nuanced and reliable predictions of future climate scenarios.

Despite all these there are few challenges of depending entirely on data driven AI process because of paucity of consistent climate related data especially in less developed countries. Along with this ethical dilemma also arises. Therefore, a hybrid approach combining of physics-based simulation models and AI driven climate models is likely to enhance the

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[1] Assistant Professor, Department of Economics, Seth Anandram Jaipuria College, Kolkata

forecasting process and improve resilience of the vulnerable communities more successfully.

Key Words: AI, Interdisciplinary research, Climate model, Ethical issues

1. Introduction

Interdisciplinary scientific research facilitated by artificial intelligence (AI) has transformed the manner in which scientists address complex challenges in diverse fields. By employing machine learning algorithms and advanced data analytics, researchers can now synthesize knowledge from multiple disciplines, thereby gaining deeper insights and developing innovative solutions. The convergence of AI and interdisciplinary research has resulted in significant advancements in areas such as drug discovery, climate modeling, and personalized medicine. The synergy between AI and interdisciplinary research has enabled the exploration of previously uncharted scientific territories. For example, AI-powered tools can analyze extensive datasets from various sources and identify patterns and correlations that may elude human researchers. This capability is particularly valuable in fields such as genomics, in which AI algorithms can process and interpret large-scale genetic data to reveal novel relationships between genes and diseases. Moreover, AI-driven simulations and predictive models allow scientists to test hypotheses and explore scenarios that are impractical or impossible to investigate through traditional experimental methods, thereby fostering collaboration across disciplines and accelerating the pace of scientific discovery.

In this paper, an attempt has been made to show how climate models have improved with the interaction of AI and interdisciplinary research in climate science. The incorporation of AI and interdisciplinary approaches has resulted in substantial progress in climate modeling, thereby enhancing the precision and dependability of climate predictions. This advancement has enabled scientists to gain a deeper understanding of and more accurately forecast complex climate phenomena. AI methodologies, including machine and deep learning algorithms, have played a crucial role in processing extensive climate data, identifying patterns, and revealing relationships that were previously challenging to discern using conventional methods.

The aim of this paper is to discuss the limitations of the traditional models and role of AI in enhancement of the existing climate models to predict climate anomalies and thus help in adaptation and mitigation process. The paper is arranged in the following manner. The first section introduces the paper. The necessity of climate modelling is illustrated in the following section. The third section discusses the traditional climate modeling techniques along with their limitations. The subsequent section elaborates how incorporation of AI improves the climate models. The fifth section highlights the limitations of using AI in climate models and role of interdisciplinary approach. The final section concludes the paper with policy recommendations.

2. Necessity of climate modelling

Climate change is an unavoidable phenomenon, and it has been established that adaptation and mitigation are the sole strategies for ensuring the planet's sustainability. The effectiveness of these strategies is contingent upon the precise measurement of climate-related vulnerabilities. Climate modeling extends beyond mere weather prediction; it deciphers the prospective trajectory of our planet. Utilizing data from satellites, sensors, and historical records, these models are grounded in intricate mathematical equations that simulate interactions among Earth's various systems, such as the atmosphere, oceans, and land. By adjusting variables like carbon emissions, deforestation rates, greenhouse gas emissions, and solar radiation, these models can project potential future scenarios. This enables scientists to comprehend not only global impacts but also regional effects, such as the potential consequences for India due to rising temperatures, shifting monsoons, or sea level rise.

Climate models serve as the foundation for international climate assessments, including those conducted by the Intergovernmental Panel on Climate Change (IPCC). These assessments influence global policies, guide climate finance, and shape adaptation and mitigation strategies for vulnerable communities. In practical terms, these models impact agriculture, urban planning, health issues, and the prediction of extreme weather events. For instance, a farmer in West Bengal might utilize regional climate projections to determine which crops to cultivate in the coming decade, while urban planners in Kolkata might rely on flood risk models to design resilient infrastructure. Governments employ forecasts from these models to evacuate vulnerable areas, such as the small coastal islands of the Indian Sundarbans, to protect them from tropical cyclones.

The accuracy of climate models is crucial for disaster preparedness and infrastructure design. A minor mistake in measurement can have havoc on the countries. Governments utilize predictions from these models to establish carbon reduction targets. For example, India's National Action Plan on Climate Change (NAPCC) relies on model data to inform its missions on solar energy, sustainable agriculture, and water conservation. Continuous refinement and validation of these models are essential to ensure they provide the most up-to-date and precise information possible. As climate change accelerates, the need for robust, localized, and actionable climate data becomes increasingly critical for decision-makers at all levels, from individual farmers to national governments.

The integration of machine learning techniques with traditional climate models offers promising avenues for improving prediction accuracy and computational efficiency. Furthermore, the development of user-friendly interfaces and data visualization tools can help make complex climate information more accessible to non-experts. Collaborative efforts between climate scientists, data analysts, and policymakers are crucial to translate scientific findings into effective adaptation and mitigation strategies.

3. Traditional Climate modeling techniques and their limitations

3.1 Traditional Climate Techniques:

Traditional climate modeling techniques serve as foundational elements in the field of climate science. Energy Balance Models (EBMs) represent one of the earliest and most straightforward approaches to climate modeling. These models primarily focus on the equilibrium between incoming solar energy and outgoing terrestrial radiation. Consequently, EBMs assess the balance of energy entering and exiting the Earth. Balanced energy equations are employed to calculate surface temperature using known variables such as zonal surface temperature and latitude-specific data. These models are not global but are one-dimensional, focusing solely on the Earth's latitudinal direction (Pirani et al. 2004). Box Models offer another traditional methodology; wherein complex systems are simplified into boxes (or reservoirs) connected by fluxes. These models depict various components of the Earth system as interconnected reservoirs that exchange energy, mass, or other quantities. Radiative-Convective Models occupy an intermediate position between simple energy balance models and complex General

Circulation Models (GCMs). Radiative-convective models provide advantages over simpler models and establish a foundation for more complex models. They can estimate both surface temperature and temperature variation with altitude more realistically. Additionally, they simulate the observed decline in upper atmospheric temperature (Boyles et al. 2024, 1008). Earth System Models of Intermediate Complexity (EMICs) represent another traditional approach, simulating Earth systems with simplifications. These simplifications render them valuable for paleoclimate studies and long-term climate projections (Soares et al. 2024, 229–259). Another significant traditional model is Statistical Climate Models, which consist of a set of physical equations for the global climate system cast in non-linear state space form, with parameters estimated using the maximum likelihood method (Gebrechorkos et al. 2023, 611). At the core of traditional climate modeling approaches are General Circulation Models (GCMs), also known as Global Climate Models. Traditional GCMs integrate fundamental physical processes over time steps ranging from minutes to hours, incorporating parameterizations for sub-grid scale phenomena such as cloud formation, precipitation, turbulence, and land-atmosphere interactions that cannot be explicitly resolved at the model's spatial scale. The two primary types of General Circulation Models are Atmospheric and Ocean models, which separately account for changes within the atmosphere and the ocean, respectively, and when combined, they constitute a comprehensive climate model. These models have traditionally relied on prescribed greenhouse gas concentrations or emission scenarios to drive climate simulations, with scenarios denoted by letter-number combinations such as A1, A2, B1, and B2, each based on complex relationships between socioeconomic forces driving greenhouse gas and aerosol emissions and the levels to which those emissions would rise during the 21st century (NOAA Climate.gov).

3.2 Limitations of the traditional models:

Traditional climate models predominantly rely on physics-based simulation frameworks, which entail significant computational demands. Simulating Earth systems at higher resolutions requires advanced computational resources and considerable processing time. Executing a single climate projection model across multiple scenarios can necessitate days or even weeks of computation on high-performance systems (Schneider et al. 2017). This computational intensity restricts the applicability of these models for real-time applications, regional decision-making, and achieving fine spatial resolution. Consequently,