

Chapter 4

AI–Driven Research Methodologies: Revolutionizing Data–Driven Discoveries in Engineering and Physical Sciences

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ABSTRACT

This chapter examines how artificial intelligence (AI) is changing how engineering and physical science researchers do their work. It demonstrates how artificial intelligence (AI)-driven technologies—like machine learning deep learning and predictive analytics—are transforming conventional approaches by making it possible to process and analyse enormous datasets at previously unheard-of speeds and precision. In fields where sophisticated simulations and data patterns have produced ground-breaking discoveries such as materials science renewable energy aerospace engineering and manufacturing the chapter explores the integration of AI in these fields. It also discusses how AI can stimulate interdisciplinary collaboration increase predictive power and improve research efficiency. The chapter also covers obstacles such as the requirement for transparent algorithms ethical issues and data biases. The usefulness of these developments is demonstrated through case studies of effective AI applications in scientific research.

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INTRODUCTION

AI is extending the set ways that studies are conducted in a variety of fields starting with engineering along with physical sciences. Engineering advances in Artificial Intelligence research are helping scientists and engineers study phenomena, process large data sets and find solutions to problems in ways that were unimaginable before. Due to recent improvements in computational power and availability to big data sets, AI has become one of the modern tools that offers innovative approaches to modelling, simulating, and experimenting with scientific data. Poring on the subject of how AI has transformed these research paradigms, this chapter examines how it assists scholars in these disciplines to achieve paradigmatic breakthroughs through data mining methodologies (Khurana, 2024). AI is useful when it comes to decentralizing research tasks, analyzing huge datasets, and producing new insights that are hard to obtain using traditional means. For instance, in engineering, applications of artificial intelligence are in identifying better ways of designing and developing materials from cardinal data deduced from experiments and simulations. In field of physical sciences, AI enables the physicists to model and predict the physical worlds at quantum level based on data generated by particle accelerators or astronomical surveys. The application of machine learning algorithms, neural networks, AI techniques are becoming prevalent in these areas, and research is becoming more effective and identification of things that human perhaps would not be able to identify (Klami et al., 2024).

However, one major strength of employing AI in the research is the capability of analyzing large data in lesser time. Indeed, due to the current nature of information production especially in engineering and physical sciences, conventional techniques of analysis are time-consuming or unsuitable. With the help of particularly machine learning and deep learning AI algorithms can both the process and the interpretation of this data occur in real time, empowering the researchers with the ability to make decisions and predictions based on the data. For example, in material science, AI can look at over millions of compounds and predict the characteristics of each to look for new materials that possess unique properties like heat or electrical conductivity. Similarly, the use of AI models in areas like climatic change whereby large volumes of meteorological data is available to improve the climate change models (Sasmal, 2023). Application of quantitative methods are especially more common in engineering and physical sciences since it enables the investigators to estimate instead of assuming. These models can be used to estimate the behaviour of various processes, for example, the efficiency of a new plane model's construction, or the chemical reaction process. Whenever AI is employed to analyse certain results obtained through a particular experiment, the involved theoretical models can be improved on and made more precise. Such a shift from theoretical to data-based

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