Chapter 12

The Role of Artificial Intelligence and Machine Learning in Simulations

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ABSTRACT

Simulation methods have long been instrumental in advancing scientific and engineering knowledge by offering valuable insights into complex systems and phenomena. However, these methods are not without their limitations, particularly in terms of computational complexity and accuracy. As simulation techniques have evolved over the years, they are increasingly yet several challenges persist. These challenges can impact the reliability, scalability, and efficiency of traditional simulation approaches. Primary limitations traditionally focus on issues related to computational complexity, accuracy, scalability, and other key factors that hinder their effectiveness. Another limitation of traditional simulation methods is the potential for reduced accuracy due

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to simplifying assumptions and approximations inherent in the models. Simulations rely on mathematical models to represent real-world systems, and the accuracy of the simulation results is only as good as the model itself.

INTRODUCTION TO AI AND MACHINE LEARNING IN SIMULATIONS

Simulation methods have long been instrumental in advancing scientific and engineering knowledge by offering valuable insights into complex systems and phenomena. However, these methods are not without their limitations, particularly in terms of computational complexity and accuracy. As simulation techniques have evolved over the years, they are increasingly yet several challenges persist. These challenges can impact the reliability, scalability, and efficiency of traditional simulation approaches. Analysis, primary limitations traditionally focus on issues related to computational complexity, accuracy, scalability, and other key factors that hinder their effectiveness. Another limitation of traditional simulation methods is the potential for reduced accuracy due to simplifying assumptions and approximations inherent in the models. Simulations rely on mathematical models to represent real-world systems, and the accuracy of the simulation results is only as good as the model itself. Traditional simulation techniques often make assumptions about the behaviour of the system being modelled to reduce the computational burden. These assumptions can include linearity, homogeneity, and the neglect of certain variables or interactions that might be important in real-world scenarios. For instance, in simulations of fluid dynamics, assumptions may be made about the properties of the fluid (such as assuming incompressibility or neglecting small-scale turbulence) to make the problem solvable within a reasonable timeframe. While these assumptions can make simulations computationally feasible, they can also lead to discrepancies between the simulated and actual behaviour of the system. In fields like materials science, for example, traditional methods may rely on simplifying assumptions about atomic interactions, which can lead to inaccurate predictions of material properties at the nanoscale.

Furthermore, the accuracy of traditional simulations is often limited by the resolution of the model. The more finely a system is modelled, the more computational resources are required. Therefore, many traditional simulations are forced to operate at a lower resolution, which can result in errors and oversights. For example, in climate modelling, simulations may only consider large-scale atmospheric patterns and omit smaller-scale processes, such as cloud formation or localized weather systems, which can impact the accuracy of long-term climate predictions. Scalability is another critical limitation of traditional simulation methods. As the