



Decoding Life with Intelligent Systems: The Role of Artificial Intelligence in Genomics

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DESCRIPTION

Artificial intelligence has become an influential force in genomics, transforming how biological data is analyzed, interpreted, and applied. Genomics, the study of the complete set of within an organism, generates vast amounts of data that require advanced tools for meaningful interpretation. Artificial intelligence provides computational methods capable of identifying patterns within complex datasets, allowing researchers to extract valuable insights from genomic information.

The human genome contains billions of base pairs, and even small variations in this sequence can have significant effects on health and disease. Traditional analytical methods often struggle to process such large volumes of data efficiently. Artificial intelligence addresses this challenge by using algorithms that can learn from data and improve their performance over time. Machine learning, a subset of artificial intelligence, is particularly useful in genomics because it can identify patterns without requiring explicit programming for every scenario.

One of the key applications of artificial intelligence in genomics is variant analysis. Genetic variations can influence susceptibility to diseases, response to medications, and overall biological function. Identifying which variations are significant among millions of possibilities is a complex task. Artificial intelligence models can analyze genomic sequences and predict the impact of specific mutations, helping researchers focus on those most likely to be clinically relevant. This capability supports faster and more accurate identification of disease-associated genes.

Another important area involves gene expression analysis. Gene expression refers to how actively a gene produces its associated product, such as a protein. Changes in gene expression can indicate disease states or responses to environmental factors. Artificial intelligence can analyze expression data from thousands of genes simultaneously, identifying patterns that may not be apparent through traditional methods. This allows

researchers to understand how genes interact within networks and how these interactions influence biological processes.

Artificial intelligence also plays a significant role in genome sequencing. Advances in sequencing technologies have made it possible to generate genomic data at an unprecedented scale. However, assembling and interpreting this data remains a complex task. Artificial intelligence-driven tools can improve the accuracy of sequence alignment, identify errors, and reconstruct complete genomes more efficiently. These improvements reduce the time required for analysis and increase the reliability of results.

In clinical settings, artificial intelligence supports personalized healthcare by integrating genomic data with other medical information. By analyzing a patient's genetic profile alongside clinical records, AI systems can assist in diagnosing diseases and recommending treatment options. This approach enables healthcare providers to consider individual differences when making decisions, potentially improving patient outcomes. For example, AI can help identify which medications are likely to be effective based on a patient's genetic makeup, reducing the risk of adverse reactions. Cancer research has particularly benefited from the integration of artificial intelligence and genomics. Tumors often contain numerous genetic alterations that vary between patients. AI models can analyze these complex patterns to identify mutations driving cancer growth. This information can guide the selection of targeted therapies, allowing for more precise treatment strategies. Additionally, AI can monitor changes in tumor genetics over time, helping clinicians adjust treatments as the disease evolves.

In conclusion, artificial intelligence is transforming genomics by providing powerful tools for analyzing complex biological data. Its applications range from variant analysis and gene expression studies to clinical decision-making and drug discovery. While challenges related to data quality, interpretability, and ethics remain, ongoing research and collaboration continue to advance this field.

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