EDITORIAL

ARTIFICIAL NEURAL NETWORKS IN PHYSIOLOGY: EMERGING ROLES IN EDUCATION AND RESEARCH

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Artificial neural networks (ANNs) have become central to biomedical science, offering new ways to understand complex physiological systems, enhance teaching, and accelerate research. Their capacity to model nonlinear biological processes makes them valuable tools for physiology education, where they support interactive simulations, adaptive learning, and computational training for undergraduate and graduate students. In research, ANNs enable the analysis of large datasets, prediction of physiological responses, and integration of experimental as well as computational approaches. Beyond these domains, ANNs support personalized medicine, real-time physiological monitoring, drug development and pharmaceutical manufacturing. As these technologies continue to evolve, their influence on physiology is expected to deepen, offering new opportunities for discovery and innovation.

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Artificial neural networks (ANNs) are computational systems inspired by the structure and function of biological neural networks. They consist of interconnected nodes ('neurons and nuclei') that process information through weighted connections, allowing them to learn patterns from data and perform tasks such as classification, prediction, and pattern recognition. Their ability to model nonlinear and multidimensional relationships makes them particularly suited to physiological systems, which often involve complex interactions that cannot be captured by simple linear models. As physiology increasingly intersects with computational science, ANNs have emerged as essential tools for understanding biological complexity.[1]

Physiology is inherently complex, requiring students to understand dynamic processes such as membrane potentials, cardiovascular regulation, and endocrine feedback loops. In physiology education, ANNs are reshaping how students engage with difficult concepts. ANNs enable the creation of interactive simulations that allow learners to manipulate variables and observe dynamic physiological responses, improving comprehension of processes such as membrane potentials, cardiovascular regulation, and endocrine feedback loops. These tools help bridge the gap between theoretical knowledge and system-level understanding, which is often challenging for students encountering physiology for the first time.[2]

ANNs also support personalized learning through adaptive educational platforms. ANN-driven systems can identify knowledge gaps by analyzing student performance data and adjust content difficulty accordingly. This approach aligns well with competency-based medical and health sciences education, where individualized progression is increasingly emphasized. Although these technologies are not exclusive to physiology, their integration into biomedical curricula is growing, offering students a more tailored and effective learning experience.[2]

At the post-graduate level, training in computational physiology is becoming more prominent, and ANNs play a central role in this shift. Students are increasingly exposed to ANN-based modelling in areas such as electrophysiology, pharmacokinetics, and systems biology. This training prepares future physiologists and biomedical scientists to work in interdisciplinary environments where computational and experimental approaches are deeply intertwined. As data-driven research becomes the norm, familiarity with ANN methodologies is no longer optional but essential.

In physiological research, ANNs have become powerful tools for modelling complex biological systems. Their capacity to capture nonlinear dynamics allows researchers to simulate neuronal firing patterns, cardiac electrophysiology, metabolic regulation, and other processes that are difficult to represent using traditional mathematical models. By integrating principles from computer science, nonlinear dynamics, and chaos theory, ANNs enable the study of emergent behaviours that arise from interactions among multiple physiological variables.

ANNs also facilitate data-driven discovery in physiology. Modern research generates vast datasets from genomics, proteomics, imaging, and wearable biosensors.[3] ANNs can identify patterns within these datasets, revealing relationships that may not be apparent through conventional statistical methods. For example, ANNs have been used to predict drug-target interactions, analyze chemogenomic space, and explore toxicity profiles, demonstrating their utility in bridging molecular data with physiological outcomes.[4]

Another important contribution of ANNs to physiology research is their ability to support hypothesis generation. By predicting the outcomes of physiological

experiments, ANN models can guide researchers toward the most promising experimental directions. This predictive capability accelerates research cycles and reduces the need for extensive trial-and-error experimentation, particularly in fields such as electrophysiology, where experimental procedures can be technically demanding and time-consuming.[2,3]

Beyond drug development, ANNs are contributing to personalized and precision medicine by analyzing patient-specific data to predict therapeutic responses.[3] This is particularly relevant in physiology-based specialties such as cardiology, endocrinology, and neurology, where individualized treatment strategies can significantly improve outcomes.[3] ANNs also support real-time physiological monitoring through integration with wearable biosensors, enabling continuous assessment of parameters such as heart rate variability, glucose levels, and respiratory patterns.[3]

The integration of ANNs with emerging technologies such as digital twins, high-throughput screening platforms, and advanced biosensors further expands their potential impact on physiology. Digital twins, that are virtual models of individual patients, use ANN-based simulations to predict physiological responses and guide personalized treatment strategies. High-throughput screening platforms incorporate ANN-driven predictions to prioritize experimental testing, improving efficiency and reducing costs.[1]

Artificial neural networks are thus reshaping physiology education, research, and drug development in profound ways. Their ability to model complexity, analyze large datasets, and generate predictive insights positions them as essential tools for the next generation of physiologists and biomedical scientists.[5] As ANN technologies continue to evolve, their integration into physiology will deepen, offering unprecedented opportunities for discovery, innovation, and personalized healthcare. At the same time, responsible implementation will require attention to issues of interpretability, bias, and ethical use, ensuring that these powerful tools contribute positively to biomedical science.

REFERENCES

1. Sullivan AM, Xia H, McBride JC, Zhao X. Reconstruction of missing physiological signals using artificial neural networks. In: Computing in Cardiology. Belfast, UK: IEEE; 2010. (pp. 317–20).
2. Rios E. Using neural networks for image analysis in general physiology. J Gen Physiol 2024;156(10):e202413623. PMID: 39287612
3. Seely AJ. Data intelligence is the future of monitoring. J Clin Monitoring and Computing 2014;28(4):325–7. doi: 10.1007/s10877-014-9561-y.
4. Zhang K, Yang X, Wang Y, Yu Y, Huang N, Li G, Li X, Wu JC, Yang S. Artificial intelligence in drug development. Nature Medicine 2025;31(1):45–9. doi: 10.1038/s41591-024-03434-4.
5. Ibarra EJ, Parra JA, Alzamendi GA, Cortés JP, Espinoza VM, Mehta DD, *et al.* Estimation of subglottal pressure, vocal fold collision pressure, and intrinsic laryngeal muscle activation from neck-surface vibration using a neural network framework and a voice production model. Front Physiol 2021;12:732244. doi: 10.3389/fphys.2021.732244

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