Anesthesiology, Intensive Care Unit (ICU) or critical care, and emergency care medicine are complex and dynamic medical specialties that converge to provide comprehensive acute care to patients with severe diseases, anesthetized, surgery, or experiencing acute conditions. These rapidly evolving fields within the healthcare landscape focus primarily on the effective management of various critical physiological parameters, including two main aspects: status monitoring (such as hemodynamics, ventilation, oxygenation, etc.) and life-supporting (such as blood product administration, medication injections, ventilator adjustment, etc.). The ultimate goal is to provide high quality patient care and to promote a favorable impact on post-discharge recovery and quality of life.

Therefore, the roles and responsibilities of specialists in these fields extend far beyond the administration of anesthesia or the simple management of acute symptoms. One of the most significant challenges for clinicians is maintaining patients in a stable and optimal physiological state throughout the acute care process. Even minor fluctuations can lead to profound consequences for patient outcomes. Obtaining and maintaining this stability is critical in various medical specialties, as it directly impacts the effectiveness of care and the patient's general health. They involve a multifaceted, effective and efficient approach that encompasses the continuous monitoring and analysis of physiological status from multiple sources, combining with patients' other clinical records or notes, and providing the appropriate targeted treatments, such as fluid administration and ventilation adjustments, aimed at timely prognosis of any changes in the patient's status and allowing for swift adjustments to physiological parameters to maintain optimal stability. This proactive approach ensures the patient's life and a recovery-oriented outcome. This process demands a comprehensive understanding of the entire human body, facilitated by closed-loop workflow thinking. As such, anesthesiologists, ICU specialists, critical care physicians, or emergency medicine professionals must maintain constant focus, possess rapid response capabilities, and use high-level skills and extensive experience to navigate complex situations over a prolonged period.

In response to this complex issue, the healthcare industry has witnessed the emergence of an interdisciplinary field that leverages the benefits of informatics, big data, and Artificial Intelligence (AI) in the clinical and medical domain, focusing on acute care medicine. Over the years, multiple innovative techniques have been developed to address this challenge, harnessing the potential of big data and AI technologies. One notable example is the development of" Robotic Anesthesia/ICU," which was first introduced in the 2000s and has gained widespread attention in recent times, particularly in response to the impact of the COVID-19 pandemic on the healthcare system. The pandemic has highlighted pressing issues, such as unbalanced allocation of medical resources and the overwhelming workload faced by critical care specialists, demonstrating the urgent need for innovative solutions. The current" Robotic Anesthesia/ICU" system is developed to employ advanced information science and automation to create a closed-loop control system, which offers improved precision and efficiency. Other automation systems, such as alarm monitors, anesthesia management systems, Clinical Decision Support System (CDSS), remote monitoring technologies, and automated intubation robots, have significantly alleviated the burden on specialists and improved the quality of medical care. These technologies simplify clinical workflows, improve patient safety, and facilitate timely interventions, ultimately contributing to more efficient healthcare delivery.

Currently, these proposed automation systems focus mainly on relatively narrow domains, such as the" Robotic Anesthesia/ICU" systems that control some specific anesthetic drug delivery through parameters related to anesthetic depth. The monitors detect specific vital signs and alert the change in physiological parameters. CDSS offers decision-making support in general clinical contexts without a deep dive into specific areas of expertise. Both systems face significant challenges in clinical practice and often do not improve the overall quality of healthcare. This issue can be attributed to the inherent complexity of the human body as a system. Despite significant advancements in medical technology and an expanding understanding of human physiology, our knowledge and management of these complexities remain rudimentary. Consequently, achieving a fully integrated automated system presents substantial challenges, indicating the need for deeper research and innovation to bridge these gaps in our understanding and capabilities.

With the rapid advancement of big data, Machine Learning (ML), and AI technologies, their remarkable capabilities in data processing, predictive analytics, and intelligent decision-making have been extensively validated in various fields, including the healthcare or clinical domain. However, the inherent end-to-end black-box effect of these algorithms AI poses significant challenges in clinical scenarios, as opaque decision-making processes make it difficult to validate their reliability and effectiveness. This lack of transparency can cause professionals to hesitate to adopt these innovative solutions fully. Clinicians often require clear, interpretable models to trust and integrate these technologies into their specialized and trainable workflows, as patient safety and treatment outcomes hinge on the efficacy of clinical interventions. Without clinical insight, aligning these tools with rigorous standards of evidence-based practice and science becomes problematic. Therefore, AI and ML applications remain a critical focus for researchers and developers seeking to foster greater acceptance and utilization of these technologies within the clinical landscape.

This research focuses on developing an automated approach to optimize physiological management in acute medicine. An automated system is initially designed according to established medical workflows, adhering to evidence-based clinical practices and thought processes. By automating clinical practices

and thought processes, this system mimics the patterns of clinicians, including goal setting, information processing, reason analysis, and decision-making, making it more acceptable in a clinical setting. This deliberate system design ensures that the automated approach remains in alignment with conventional clinical methodologies, guaranteeing the highest efficacy and reliability. Furthermore, AI models are seamlessly integrated into these medical workflows to enhance various aspects of the system and improve intelligence in data processing, decision-making, reason analysis, etc. This, in turn, amplifies the system's automatic processing and decision-making capabilities, enabling more efficient physiological status management in acute care medicine and finally enhancing its overall performance and capabilities.

Keywords: Anesthesia and critical care, automated physiological management, monitoring, clinical decision making, AI and big data