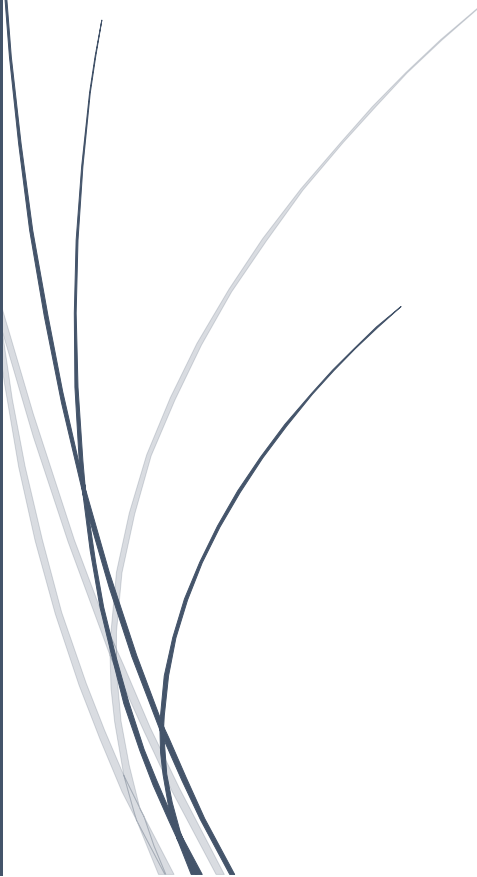


Implementation of edge computing and AI for ultra-fast processing in smart prosthetics and implants

Abstract line art consisting of several thin, curved lines in dark blue and light grey, originating from the bottom left and extending upwards and to the right.

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Implementation of edge computing and AI for ultra-fast processing in smart prosthetics and implants

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Abstract

The integration of edge computing and artificial intelligence (AI) in smart prosthetics and implants represents a significant advancement in healthcare technology, enabling ultra-fast processing, real-time decision-making, and enhanced user control. This chapter explores the critical role of edge AI in addressing latency and computational constraints in prosthetic systems, focusing on hardware acceleration techniques, real-time data acquisition, and neural signal processing. By leveraging edge computing, prosthetic devices can achieve low-latency performance, providing users with seamless interaction and improved functionality. Additionally, the chapter delves into the impact of AI algorithms in optimizing control, offering insights into adaptive learning and neural interface technologies that contribute to more intuitive and responsive prosthetics. The challenges of balancing bandwidth, latency, and computational power in edge-based prosthetic systems are also examined, with a focus on strategies for minimizing delays and enhancing system efficiency. The convergence of AI, edge computing, and prosthetic technologies promises to revolutionize the field, offering users enhanced comfort, mobility, and performance.

Keywords: Edge computing, artificial intelligence, prosthetics, latency reduction, real-time processing, hardware acceleration.

Introduction

The rapid advancements in edge computing and artificial intelligence (AI) are redefining the future of prosthetics and implants [1]. Traditionally, prosthetic devices have faced significant challenges related to latency, computational limitations, and real-time data processing [2]. These challenges often hinder the performance and usability of the devices, making them less intuitive for users [3]. The integration of edge computing enables local processing of data, allowing prosthetic systems to perform faster and more efficiently by minimizing reliance on cloud computing [4]. AI algorithms play a pivotal role in enhancing the decision-making capabilities of prosthetics, enabling them to adapt to a user's unique movements and behaviors [5]. By embedding

intelligent processing directly within the device, edge computing and AI work together to provide ultra-fast, responsive prosthetics that more closely mimic the functionality of natural limbs [6].

Latency remains one of the most critical factors affecting prosthetic performance. Delays between the user's intended movement and the prosthetic's response can disrupt the sense of control, resulting in frustration and reduced functionality [7]. The role of edge computing in overcoming this challenge is particularly significant, as it enables the real-time processing of data directly at the point of use [8]. Instead of sending data to the cloud for analysis, edge devices can process it locally, significantly reducing transmission delays [9]. This enhances the prosthetic's ability to respond to user inputs immediately, ensuring smoother, more seamless interactions that are critical for tasks requiring high precision, such as grasping or manipulating objects [10].

Real-time data acquisition and processing are critical components of successful prosthetic systems [15]. Sensors embedded in the prosthetic devices gather continuous feedback, which is essential for interpreting the user's movements and intentions [16]. This real-time data is then processed by AI algorithms, which need to make quick decisions regarding the appropriate action for the device to take [17]. Edge computing technology facilitates this process by bringing the data processing capabilities closer to the point of collection, minimizing delays and ensuring immediate feedback [18]. This is especially important in complex movements that require constant adjustments, such as walking, running, or performing intricate hand movements [19]. Ensuring that data is processed locally allows the prosthetic to adapt in real-time, reducing the lag and improving overall system performance [20].