Chapter 7
The Emerging Role of Advanced Technologies in Neurological Diseases: Leveraging Facial Electromyography for Enhanced Emotion Recognition in AI Systems

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ABSTRACT

Interpreting human emotional states is crucial for advanced AI in human-computer interaction. Addressing this need, we propose a comprehensive methodology centered on facial Electromyography (fEMG) signals. fEMG offers a direct, objective measure of muscle activation for genuine emotional responses. We detail a complete pipeline: from fEMG acquisition to advanced time-frequency analysis using Continuous Wavelet Transform (CWT). This robust feature extraction integrates with machine learning models for emotion classification and prediction. Leveraging fEMG's temporal dynamics, we aim to enhance emotion recognition system accuracy and real-time capability. This chapter addresses the methodology and demonstrates its effectiveness through the rigorous validation of its evaluation framework, rigorously

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validated, demonstrating exceptionally consistent performance in both continuous regression and discrete classification tasks with simulated data. This strong alignment between predicted and ground truth confirms the reliability and correctness of the pipeline depoloyed.

INTRODUCTION

The rapidly evolving field of artificial intelligence (AI) is increasingly prioritizing the ability of systems to comprehend and respond to human emotions (Picard, 1997; Tao & Tan, 2023). This transition from purely functional interfaces to emotionally intelligent systems is vital for fostering more natural, intuitive, and personalized user experiences, ultimately leading to advanced adaptive interfaces (Calvo & D'Mello, 2010; Harper et al., 2019). In this chapter, we address the critical need for robust emotion recognition by proposing a comprehensive methodology centered on facial Electromyography (fEMG) signals. Such empathetic understanding can significantly enhance user satisfaction and enable interfaces to dynamically adapt to individual needs and moods.

Emotion recognition provides crucial insights into users' affective states, with profound implications across various sectors, particularly healthcare. In clinical settings, monitoring emotional well-being can support the early detection and management of conditions like depression or anxiety, leading to more timely and effective interventions (Harper et al., 2019). Beyond clinical diagnosis, real-time emotion monitoring can also improve patient engagement in therapy and rehabilitation (Wang et al., 2022).

While emotions can be inferred from diverse modalities such as facial expressions, vocal inflections, and body language (Kim & André, 2008; Ringeval et al., 2021), physiological signals offer a unique and often more objective pathway to discerning genuine emotional responses (Kim & André, 2008). Among these indicators, facial electromyography (fEMG) stands out due to its direct measurement of the subtle muscle activation patterns underlying emotional expressions. The precise electrical activities captured by fEMG electrodes provide a robust and less consciously controllable window into an individual's affective state, making it a highly reliable modality for emotion recognition (Kołodziej et al., 2024).

This paper presents a comprehensive methodology for the acquisition, processing, and advanced analysis of fEMG signals, leveraging techniques such as the Continuous Wavelet Transform to extract meaningful features. Our work aims to demonstrate how these precisely characterized fEMG patterns can then be utilized to accurately classify and potentially predict emotional states, thereby contributing significantly to the development of more responsive and human-aware AI systems.

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