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Doctoral Dissertation

Doctoral Program in Computer and Control Engineering (38<sup>th</sup> cycle)

**Deep learning and computer vision  
approaches for clinical support: from  
cognitive impairment detection to  
pediatric care**

By

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## Abstract

This PhD research explores the application of deep learning and computer vision to support clinical decision-making in cognitive impairment detection and pediatric care. Central to this approach is the analysis of camera-based data, which provides a non-invasive and accessible way to capture subtle behavioral and emotional signals relevant for clinical assessment.

Dementia is the most common neurodegenerative disorder and a major cause of disability in the elderly. Although no definitive cure is currently available, emerging treatments show promise if administered at a very early stage. Early detection is therefore essential, both to improve patients' quality of life and to enable their participation in clinical studies. In individuals with cognitive impairment, facial expressions are often altered, with distinct patterns across dementia types. This research investigates facial expression analysis as a potential non-invasive biomarker to support early detection and differential diagnosis. An artificial intelligence-based system is proposed to detect cognitive impairment through facial emotion analysis, achieving 76.0% accuracy in distinguishing individuals with mild cognitive impairment from healthy controls and 75.4% accuracy in discriminating Alzheimer's disease from other forms of cognitive decline. These findings highlight the promise of the proposed approach as a supportive tool for early and differential diagnosis of dementia, moving toward non-invasive screening methods.

Beyond cognitive impairment, this research also extends to pediatric care, focusing on the crucial challenge of automatic and contactless pain assessment in newborns and young children. Infants and non-verbal children are often unable to express their discomfort clearly, making it challenging for healthcare professionals to accurately assess and respond to their pain. Traditional methods, based on subjective observation and scoring systems, can be inconsistent and time-consuming. An artificial intelligence-based approach analyzing facial expressions, body movements, and

other visual cues offers a more objective solution, reducing medical staff's burden while improving the quality of care. In this research, a camera-based system is proposed for the automatic detection of behavioral parameters, and the feasibility of its usage in the Pediatric Emergency Department is evaluated. Additionally, a deep learning framework is introduced for newborn pain assessment through facial expression analysis in the Neonatology Department, reaching 88.8% accuracy in pain detection. Results confirm the feasibility of automated pain detection in real-world conditions, including scenarios where pain management strategies, such as pacifier use, are applied. By embedding explainable artificial intelligence, model transparency and trust among healthcare professionals are strengthened. This work lays the foundation for automated systems capable of integrating, standardizing, and enhancing human pain assessment in clinical practice.

Recently, Large Language Models have emerged as promising tools to support pediatric care. Yet, their effectiveness in assisting the diagnostic process within the Pediatric Emergency Department remains largely unexplored. To address this gap, the diagnostic performance of five state-of-the-art Large Language Models is evaluated against physicians on real pediatric emergency cases of varying complexity. Results show that advanced models can achieve diagnostic accuracy comparable to, and in some cases surpassing, that of experienced clinicians. These findings underscore the potential of Large Language Models as supportive assistants in pediatric emergency care, enhancing clinical decision-making without replacing physicians' judgment, while emphasizing the need for structured protocols to ensure their safe and effective integration into practice.