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A Hybrid Biosignal System for Accurate Pain Classification: A Review

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Pain is a multifaceted and subjective phenomenon, particularly challenging to evaluate in nonverbal pediatric postoperative patients and those with cognitive impairments. While self-reporting has traditionally been regarded as the gold standard, new methodologies are emerging that incorporate wearable sensors alongside physiological monitoring and behavioural analysis using Machine Learning (ML) and Deep Learning (DL). The signals monitored include Electroencephalography (EEG), Electromyographic activity (EMG), Electrodermal/Galvanic Skin Response activity, Photoplethysmographic activity (PPG), Electrocardiographic activity (ECG), respiration, facial expressions, body posture, and vocalizations. Multimodal fusion techniques surpass those that rely on single-signal approaches. The most frequently utilized algorithms include support vector machines, convolutional neural networks, long short-term memory networks, and transformers, which generally achieve accuracy rates between 70% and 90%. The primary obstacles faced include limited datasets, variability, label noise, and the need for clinical validation.

Keywords: EEG, EMG, EDA, PPG, Pain assessment

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