

Development of an Intelligent Edge-Computing Algorithm for the Prediction of Workforce Productivity and Physiological Load in Manual Material Handling

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Abstract

Manual material handling remains a physically demanding activity with significant implications for workforce productivity and occupational health. While remote laboratory assessments exist, there is a lack of localized, field-ready systems capable of analyzing worker strain on-site. This study presents the development of an intelligent edge-computing algorithm designed to predict worker fatigue, physiological load, and productivity in real time. The algorithm leverages locally acquired anthropometric, physiological, and lifestyle data, collected via heart rate monitors, digital sphygmomanometers, pulse oximeters, and goniometers, to compute predictive metrics such as energy expenditure (EE), maximal oxygen uptake (VO₂max), and task-specific work capacity. Input data are processed through a multivariate regression-based model embedded within a graphical user interface, enabling immediate prediction of individual worker performance without relying on external cloud infrastructure, which is ideal for resource-constrained industrial settings. Empirical validation using an experimental dataset revealed prediction errors of 7.39 percent, 8.54 percent, and 9.89 percent for VO₂max, EE, and productivity, respectively, demonstrating strong agreement with measured values. The framework further integrates environmental variables, including core and skin temperature and ambient conditions, to refine performance forecasts under varying work scenarios. By combining wearable sensor inputs with edge-computation algorithms, the system facilitates informed job placement, workload allocation, and occupational health monitoring. The results indicate that edge-deployed predictive analytics can enhance workforce management, reduce overexertion risk, and optimize operational efficiency, bridging the gap between physiological monitoring and actionable workforce insights.

Keywords: Edge computing; Workforce productivity; Physiological load; Wearable sensors; Ergonomic assessment