Predictive Operator Assessment in Industry 5.0

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Abstract. The transition to Industry 5.0 underscores a critical shift toward human-centric manufacturing, motivating the need to bridge the gap in systems for the proactive assessment of human operators. To address that, this paper introduces a conceptual framework that integrates data collection, analytics, and targeted interventions to enhance the safety and well-being of operators in Industry 5.0 settings.

Keywords: Industry 5.0 · Predictive Assessment · IIoT.

1 Introduction

The paradigm transition from Industry 4.0 (I4.0)'s automation and digital interconnectivity to Industry 5.0 (I5.0) introduces a pivotal shift towards human-centric manufacturing processes, emphasizing sustainability and worker well-being [3].

That perspective shift increases the need to proactively assess human operators in the industrial environment, an under-explored domain.

Therefore, the first milestone of this work is developing a taxonomy of the critical human factors that should be tackled to improve operators' welfare. Then, our research merges I4.0's technological foundations with I5.0's principles to introduce a novel conceptual framework designed for proactively assessing all these aspects altogether, prioritizing our most valuable resource in the industry: human operators.

2 Related Works

The limited yet notable I4.0 literature that addresses human factors was leveraged to develop the taxonomy of critical factors influencing operators in industry illustrated in Figure 1. This will be the foundation of this work, defining the aspects the framework will address.

The authors described a more complete version of this work, including a comprehensive literature review, a more exhaustive explanation of these factors, and a detailed analysis of the framework's components, in [6].

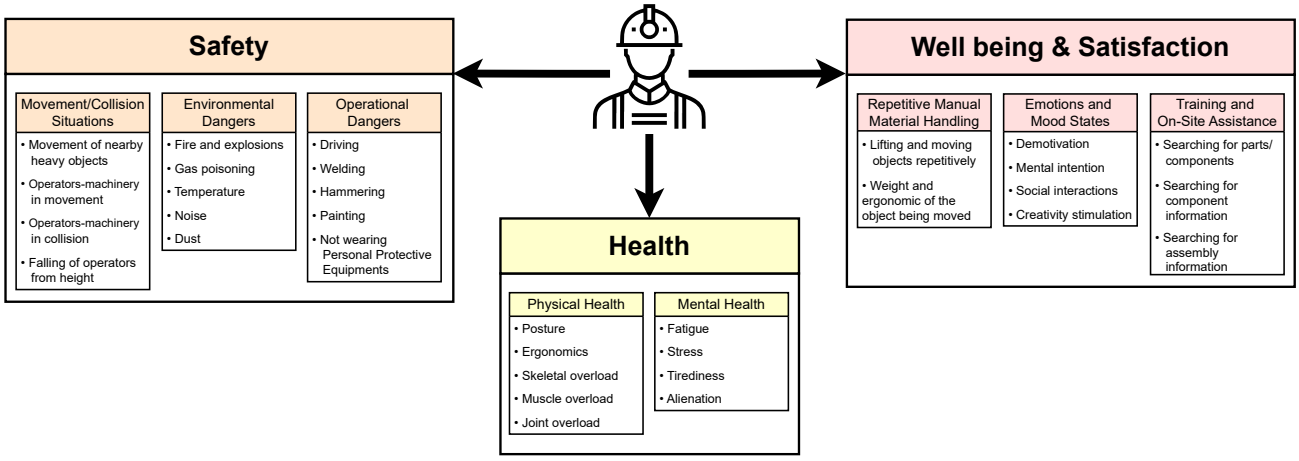

Fig. 1. Taxonomy of the human factors covered by the framework

3 Framework Architecture

The developed conceptual framework, illustrated in Figure 2, integrates a closed-loop system designed to enhance the safety, health, and well-being of operators in I5.0 settings by focusing on three interconnected modules:

1. **Data Collection Module**: This module uses a variety of IoT sensors [4], wearable devices [5] [7] , and imaging systems [2] to collect a comprehensive range of data, including physiological data and movements of operators, operational status of machinery, and environmental conditions
2. **Data Analysis Module**: This module processes and analyzes the collected data by combining machine learning techniques with human oversight to identify and predict risks and deviations from normal operational patterns, enabling the triggering of immediate responses to both prevent accidents and respond to incidents that have already occurred [5]. Additionally, digital twins are used to simulate various scenarios and forecast potential issues [7].
3. **Intervention Techniques and Predictive Assessment Module**: This module uses the insights generated from the Data Analysis module to implement targeted interventions that ensure the operators' safety and well-being. It monitors and predicts physiological and psychological states to preemptively address health risks [1], uses location data to enhance operators' safety in specific areas [2], and employs enhanced reality technologies to provide adaptive training and assistance in real-time [8].

4 Conclusions and Future Works

In this paper, we introduced a novel framework that integrates various I4.0 technologies into components specifically designed to proactively assess human operators, including predictive intervention techniques that actively respond to

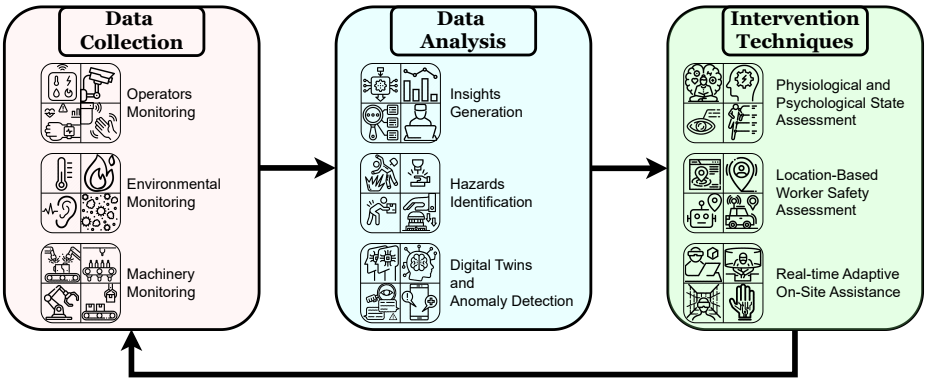

Fig. 2. Flowchart of the proposed conceptual framework

and anticipate operational conditions. Additionally, the closed-loop system enables the continuous evaluation and adjustment of these interventions. This work sets a new standard for predictive systems in industrial settings, advancing the alignment with the human-centric model of I5.0.

Future research must improve real-time data processing and aggregation techniques and develop adaptive interventions tailored to individual needs to enhance the framework's effectiveness and adaptability.

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