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Modeling a Human-Centric Framework to Link Cognitive Factors and Maintenance Reliability in HRC Systems

In the Industry 5.0 transition, Humans and Collaborative Robots (Cobots) work together in different operations.. In maintenance ,the role of Human-Robot Collaboration (HRC) is becoming increasingly crucial for achieving sustainable efficiency and human-centered automation. While Collaborative Robot (Cobot) design takes into account worker safety, ergonomics, and process precision, it is necessary to consider aspects such as psychological stress in human operators that may lead to uncorrect operations and uncertainty. In maintenance activities, this stress can compromise the operations and the related quality, leading to increased defect rates, accelerated component degradation, and economic losses. Despite many studies on Human Reliability Analysis (HRA) and Human–Robot Interaction (HRI), there is no integrated quantitative framework that connects trust, stress, and repair reliability within maintenance operations.
The ongoing study proposes a dynamic model linking operator trust and stress to maintenance performance and post-repair degradation in HRC environments. The model will consider and quantify the effect of trust level on operator stress, determine the probabilistic relationship between stress and repair accuracy, and evaluate the overall economic implications, including rework and downtime costs. The analytical core of the framework is based on a Weibull reliability formulation extended with a cognitive stress factor. The resulting equations describe the probability of repair failure as a nonlinear function of trust-induced stress.

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