HÖGSKOLAN
I SKÖVDE

2026-04-08

Final PhD Thesis Evaluation - Reviewer's Report

"Human Cognitive Load and Awareness Monitoring Using AI and Biosignals in Assembly Operations"

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Reviewer: Professor Peter Thorvald, University of Skövde, Sweden

1 General assessment

This dissertation addresses the monitoring of cognitive load and awareness in assembly-related work using physiological signals and data-driven models, and places this within a broader conceptual framework, Extended HAAS, intended for human-centred and adaptive production systems. The topic is relevant and timely, and the dissertation combines conceptual work with several experimental studies covering dual-tasking, task switching, instruction design, and multitasking in human-robot collaboration.

Overall, the dissertation presents a coherent line of work and demonstrates solid competence in experimental design, signal processing, and applied modelling. The work is technically demanding and positioned in an interdisciplinary field that is both scientifically relevant and practically important. One of its main strengths is that it does not rely on a single study or a single type of measure, but instead combines physiological, behavioural, subjective, and performance-related perspectives across a series of related experiments. The dissertation also shows a generally careful treatment of methodological limitations, particularly regarding the use of HRV in short and event-based recordings.

2 Limitations

At the same time, the dissertation has a number of limitations that should be clearly acknowledged in the final assessment.

2.1 Conceptual limitations

The most important weakness is conceptual. The thesis uses cognitive load as a central concept, but the distinction between cognitive load, mental workload, mental effort,

mental demand, arousal, and attention is not sufficiently clear throughout the text. The terminology shifts over the course of the dissertation, and it is not always evident whether these constructs are treated as distinct, overlapping, or interchangeable. This does not invalidate the empirical work, but it weakens the theoretical precision of the overall argument and makes some interpretations broader than they should be.

Another limitation concerns the Extended HAAS framework itself. The framework is ambitious and interesting, but the dissertation remains somewhat unclear regarding who the actual end user of the system is and how it would be used in practice. It is not entirely clear whether the intended user is the operator, a system designer, a production engineer, a supervisor, or an automated adaptive system. Likewise, the real-time ambitions of the framework are stronger than the demonstrated implementation. The dissertation argues convincingly for the importance of real-time assessment, but it does not fully show how such a system could integrate and interpret multiple data streams quickly and robustly enough for practical industrial use.

2.2 Validity

A related concern is the use and interpretation of subjective workload measures, especially NASA-TLX. NASA-TLX is primarily an instrument for overall task workload rather than a specific measure of cognitive load or mental workload in a narrow sense. In tasks that are predominantly mental or predominantly physical, aggregated NASA-TLX scores may distort the construct of interest rather than capture it cleanly. This is particularly important in a dissertation that claims to study cognitive load specifically.

The ecological validity of the empirical studies is also limited. Several of the studies rely on small sample sizes and controlled laboratory conditions. This is acceptable to a point at the doctoral level, especially in exploratory and technically demanding work, but it does limit generalisability and weakens the practical claims regarding real industrial environments. The dissertation would have been stronger had it included at least one study in a more realistic shop-floor setting or offered a more explicit rationale for why this was not feasible within the scope of the work.

There are also some specific modelling choices that remain open to criticism. The task classification used in Extended HAAS, for example routine versus non-routine, cognitive versus physical, and individual versus social, is useful as a high-level simplification, but it risks presenting tasks as more discrete than they really are. Many industrial tasks contain mixed characteristics and shift along these dimensions over time. Similarly, while the choice of HRV and EDA is understandable and well motivated from a practical sensing perspective, the dissertation would have benefited from a more explicit justification of why these signals were prioritised over other potentially more sensitive indicators.

3 Final recommendation

Despite these concerns, my overall assessment is positive. The dissertation does not present a fully validated closed-loop adaptive assistance system, and its conceptual framing could be sharper. However, it does provide a meaningful and technically solid

contribution at the intersection of cognitive ergonomics, physiological monitoring, and human-centred production. Its strongest contribution is methodological and conceptual groundwork rather than a complete deployed solution, but that is still a valid and sufficient contribution for a doctoral dissertation.

The candidate demonstrates good scientific judgement, appropriate methodological competence, and an ability to carry out independent research in a challenging interdisciplinary area. The limitations noted above are important, but they are not, in my view, of such magnitude that they outweigh the strengths of the work.

Final recommendation:
Recommended for acceptance

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