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Digital Workplace Stress Management: A System for Digital Ergonomics Assessment in the BMW Group

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Abstract: The BMW Group has developed its own tool for ergonomic, and hazard and risk assessments: SERA (Safety and Ergonomic Risk Assessment). This system is used across all international locations in the BMW Group. The DWSM (Digital Workplace Stress Management) project has the aim of automatically, objectively, and digitally capturing the postures and forces relevant to a SERA assessment. To capture the data, a motion-capturing system and force measuring glove are used. The ergonomic assessment is determined from these two systems both analytically but also using machine learning algorithms. The major benefits of the DWSM in regard to ergonomic analyses is objectivity, improved data quality, and reduced assessment time.

Keywords: ergonomic assessment, motion capturing, force glove, digital assessment, machine learning

1. Introduction

According to the Department for Work Safety and Medicine (BAuA), work-related musculoskeletal disorders (WMSDs) are the most common cause of worker absenteeism in Germany (BAuA, 2019). An integral part of the legally mandated hazard and risk assessment at any workplace is the consideration of physical stresses (ergonomics), which are known to be the leading cause of WMSDs (DGUV, 2013). The form of ergonomics assessment, however, is not prescribed.

The BMW Group has opted for a wholistic approach in performing ergonomics assessments. The IT-system SERA (Safety and Ergonomics Risk Assessment) was designed to harmonize ergonomic assessments with the classic hazard and risk assessment (Dehghani et al., 2021; Snell et al., 2021). The internally developed, web-based, application enables a centralized and internationally comparable platform for risk management. A typical assessment with SERA (as with most other methods) relies on observations of the workplace. Despite the heightened accuracy of SERA, thanks to the automotive-specific focus of the system, a manual ergonomics assessment still has inherent limitations. Due to such limitations, and since the rollout of SERA, an alternative, digital, and objective method for performing assessments began development.

2. Digital Workplace Stress Management

2.1 System Overview

A digital assessment of ergonomic stresses has three primary goals:

1. objective data,
2. increased data quality, and
3. reduced assessment time and effort.

Based on these three goals, an extensive search was performed on the market to identify suitable technologies, which could fulfill the requirements of an automotive production setting. Following testing of various systems, an IMU-based (inertial measurement unit) motion-capturing system was selected to capture the postural stresses, and a force measuring glove for the forces and loads. Studies have demonstrated that modern IMU-based motion-capturing systems show good correspondence with optical systems (e.g. Vicon) for calculated joint angles (Benjaminse et al., 2020; Dinu et al., 2016; Paulich et al., 2018).

The other component of DWSM is a force measuring glove, which can directly capture relevant assembly forces in the line, while associates perform their work. Each fingertip and the palm of the hand carries one sensor, whose force values are captured wirelessly using the manufacturer's app. In combination, these two measurement systems enable the capture of nearly all relevant ergonomic stresses in an automated fashion.

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2.2 Methodological Background

The stresses considered in SERA are based on a variety of international standards and assessment methods. Common to many ergonomics methods, the postural stresses (neck, shoulder, and back) are classified based on certain angle ranges. Such stresses can be objectively determined directly from the motion capturing data (rather the resulting human model). For the remaining stresses, it is not possible to determine these from the motion-capturing data alone and therefore required the use of the force measuring glove. For those familiar with the Key Indicator Method (KIM), posture is a factor which is considered in the assessment of these stresses, along with the force direction, repetition rate, and the force itself. By synchronizing the data between these two systems, force events can be matched with the respective motion-capturing data following an assessment.

For the above noted reasons, it was determined that a machine learning approach was required to solve the noted issues. Over a period of several weeks, over 4600 example tasks were carried out and recorded at the BMW training center, which were to serve as the training data for our machine learning algorithms. After numerous optimizations the final precisions of the algorithms for identifying the force direction, classifying a one- or two-handed force, and classifying as a force or load were 80%, 95%, and 89% respectively.

2.3 Assessment Methodology

Performing an ergonomics assessment with DWSM is relatively easy, in comparison to a typical manual assessment (see Figure 1). To record a workplace, an experienced associate is first fitted in the motion-capturing suit and dons the force measuring glove. Following a brief calibration procedure, the work cycle is performed as usual, and the data is recorded. The assessor merely monitors the data coming in from both systems to ensure that there are no issues with either system or the wireless connections. In comparison, a typical manual assessment requires a high degree of subjectivity in determining the postural stresses and the separate measurement and evaluation of forces. Depending on connectivity in the production (not always given) the values must further be manually transferred to the SERA system to complete the evaluation.

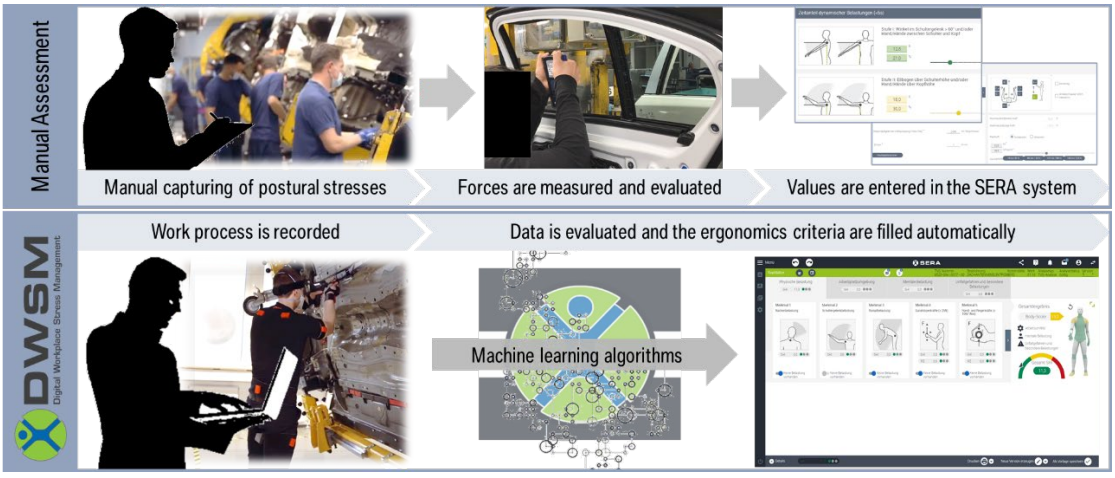

Figure 1. A comparison of processes for both a manual and DWSM assessments.

3. Conclusion

SERA is an international assessment tool for assessing ergonomics and performing hazard and risk analyses which was developed internally at the BMW Group based on the most up-to-date scientific findings. DWSM further enables SERA to capture the ergonomic stresses using a motion-capturing system and a force measuring glove. The advantages of using DWSM to perform the assessment are a reduced assessment time, increased objectivity, and improved precision. Depending on the type of ergonomic stress, a combination of analytical and machine learning algorithms were developed at the BMW Group based on thousands of training data. Further algorithms were also developed to provide a greater granularity on the types of forces experienced in a production setting, e.g. the snap-in point detection. DWSM is current undergoing the international rollout and will continue development based on user feedback and field experience.

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