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On the use of Virtual Reality for a human-centered workplace design

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Abstract

In the Industry 4.0 and digital revolution era, the world of manufacturing industry is experiencing an innovative reconfiguration of design tools and methodologies, with a different approach to the production processes organization.
The design philosophy is changing, integrating to engineering contribution interpretative aspects (design thinking), executive practices (design doing) and cognitive aspects (design cultures). The design becomes human–centered.
The new Virtual Reality technologies allow to validate performances of designed products and production processes by means of virtual prototypes in a virtual simulated environment. This approach generates several benefits to the companies, in terms of costs and time, and allows optimizing the assembly line design and related workplaces, by improving workers' benefits too.
This paper proposes an innovative method to validate the design of workplaces on automotive assembly lines in a virtual environment, based on ergonomic approach, according to ERGO – Uas system, applied by FCA (Fiat Chrysler Automobiles) groups, that integrates UAS method for measurement and EAWS method for biomechanical effort evaluation.
Creating 3D virtual scenarios allows to carry on assembly tasks by virtual manikins in order to be evaluated from different points of view. In particular, data coming from the simulation can be used to assess several ergonomic indexes, improving safety, quality and design.
The analysis is supported by the use of a motion capture system, developed by the University of Campania and composed of wearable inertial sensors, that estimates the attitude of fundamental human segments, using sensor fusion algorithms based on Kalman filtering. In this way, it is possible to make a further design validation, assessing the EAWS index basing on posture angles trends evaluated.
This method can represent an innovation for human-centered design of workplace in developing new products, reducing costs and improving job quality.

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Keywords: Virtual reality, simulation, product feasibility, design, ergonomics, motion capture, manufacturing.

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1 Introduction

The world of manufacturing industry, during the last years, is knowing a period of changes, thanks to the increasing use of new technologies in the factories that allows the chance to make them more flexible and collaborative, in order to satisfy the current demands of an increasingly competitive market. In fact, with the new production paradigm, named Industry 4.0, factories are becoming smart, characterized by cyber-physical systems that can interact between themselves, simulating the real world in a virtual scenario and making decision based on numerical analysis.

Modern factories cannot ignore the continuous development of virtual reality software. For this reason, an important aspect of Industry 4.0 is represented by Digital Manufacturing (DM), the industrial declination of virtual reality, that integrate a wide set of technologies to support the production, from the design to the product realization, monitoring and optimizing the production processes. By means of the use of PLM (Product Lifecycle Management) software, regarding process production design, it is possible generate several benefits, principally in designing manual workplaces and defining cycle time.

Integrating ergonomic aspects in design allows the opportunity to design workplaces, in particular the manual ones, with a human-centered approach. The new technologies allow to validate the performance of the workstations designed in a virtual scenario, where it is possible to simulate manual tasks and evaluate ergonomic indexes, which the design in based on.

Fiat Chrysler Automobiles (FCA) developed a preventive ergonomic method in designing new workplaces: Ergo-UAS. This method is applied during both Process/Product Design and Process Industrialization and it is composed by EAWS (European Assembly Work Sheet) and UAS (Universal Analyzing System). EAWS (Schaub, et al. (2012)) is a first level ergonomic screening for the evaluation of biomechanical overload risk. The UAS is a typical example of MTM (Method-Time-Measurement) system which is used for the definition of times and methods of work, describing the sequence of operations of a specific work task, assigning a predetermined standard time from the direct observation of the worker and the nature of the movements during the given task.

In order to achieve these results, a lot of information, principally related to human factors, are necessary to satisfy ergonomic standards, in particular that ones concerning postural aspects and effort exerted by the workers by means of innovative tools (Spada, et al. (2015)).

To prove the effectiveness of the proposed strategy and to compare simulation results with real experimental data, a modular motion tracking system, based on inertial sensors (Caputo, et al. (2016) and Caputo, et al. (2017)), has been developed at the Dept. of Industrial and Information Engineering of the University of Campania *Luigi Vanvitelli*, and used during real work tasks execution.

The aim of this research is to propose an innovative method for the validation of workplaces performance in a virtual environment followed by a further validation in physical world, using the motion capture system developed for this research.

According to this approach, it is possible to realize human-centered designed workplaces, allowing, on one hand, costs and time reduction, and, on the other hand, a workers' well-being improvement.

2 Materials and methods.

2.1 Ergo-UAS system for workstation design

The product development in a typical industrial environment, above all in automotive field, consists in four phases: style definition, design, engineering and production.