Ergonomics 4.0: The Role of Human Operator in the Future Smart Production Environment

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EDITORIAL

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The forthcoming era of industry 4.0 is promoting the spread of cloud and Internet of Things (IoT) technologies as the key-enablers of a new interconnected working environment where machines and human operators are supposed to cooperate together within a smart production system. Coherently with such view, the manufacturers of operating machines are implementing artificial intelligence in their products, transforming automated machines into cyber physical systems (CPS), with advanced interoperability features and ideally capable of coordinating with each other autonomously. CPS are thus supposed to be the manufacturing resources of next generation capable of interacting with each other, with the environment and with the human operators in seamless integrated production environment.

This idyllic view of the future smart production systems arises some fundamental questions about the role of the human operator in the working environment of the future, and how will this interaction with smart CPS take place. The risk of underestimating such issues, leaving the man in the background of an industrial revolution focused on technology, actually exists and it would eventually lead towards a general deterioration of the worker's physical and psychological condition. Unfortunately, we have recent experiences which ring an alarm bell in such sense. For example, the accident occurred last year to the Lion Air Flight 610 which crashed just minutes after taking off from Jakarta, Indonesia, killing 189 people can actually be analysed from the above discussed perspective. In such accident, the flying recording system clearly showed several pilot's efforts in counteracting the action of the anti-stall automated system, which, is considered responsible of the crash. Apparently the same situation repeated some months later, to the Ethiopian Airlines Flight 302, crashed minutes after take-off, where all the 157 people on board died. In both these disasters, the automation system is at the heart of the inquiries, with animated debates about its development and implementation process. Rather than discussing the effectiveness of the system, however, in this case we rather want to focus on the pilot's struggle in his personal fight against the machine during the few minutes preceding the crash. Now in this situation some important considerations arise: investing in technologies and increasing the technical features of the machines, or their autonomic capabilities is nothing wrong, but leaving the human being in the frustrating situation of being incapable of counter-acting an automated system even with a disaster occurring should make us reflect. Rethinking appropriately the role of the human operator in the production system is probably the main challenge that must be taken up by ergonomics in the 4th industrial revolution. Focusing on new methods and technologies for enabling a better human-computer interaction, in order to ensure a safe and healthy workplace, is an objective of paramount importance for an appropriate design and development of smart production systems.

The shift towards autonomous production environment will drastically change the way human operators will interact with the surrounding production environment, and physical operations will be replaced by cognitive tasks performed through advanced human-machine interfaces. The issues related to next generation human-machine interaction and worker's wellbeing should also be discussed in consideration of the ageing process that is affecting the workforce of many industrialized countries. The European population is in fact projected to grow from 507.2 million in 2013 to 522.8 million in 2060, with the percentage of seniors (65 years or older) forecasted to grow by 10%, while the working age population is expected to drop by 9.4% over the same period. A similar trend is observed in the USA, where in 2016, people over 65 years old comprised 18.6% of the adult working population (over 16 years), and this percentage is projected to grow by an average of 0.6% per year until 2026. In Japan, more than 25% of the population were aged 65 years and older in 2014, and this percentage is expected to reach 40% by 2060 (Debroux 2016; Collins and Casey 2017; The Economist 2017). In a manufacturing environment, human operators' capabilities of performing a task, requiring physical and/or cognitive efforts generally diminish with ageing (Gonzalez and Morer 2016; Strasser 2018). However, the impact that this decrease can have on the system's productivity can be minimized if the workplace is healthy and safe.

On the basis of such premises, we can state that the substantial changes occurring in the workplaces in the immediate future, call for an urgent improvement of the technologies and methodologies currently employed in ergonomics. Currently, ergonomics is still evaluated in many cases with standard pen-and paper worksheets filled by experts observing the workers doing their job (Li and Buckle, 1999). In the best case, such reports are finally processed with statistical tools, and the results obtained can be exploited to improve the design of the machines. Nevertheless, currently available technologies could easily allow for a real-time analysis of the workers exposure to health and safety risks. In the smart interconnected manufacturing environment proposed by industry 4.0 one would easily imagine a seamless interconnection of the workers, equipped with sensing devices capable of measuring the exposure towards vibrations, or the presence of unhealthy substances in the air, or the presence of stress makers in the biological fluids (e.g. sweat). Real-time evaluation of workers' wellbeing and safety conditions, could allow triggering immediate corrective actions or, at least, workers could be made aware of the behaviours to avoid. Such approach could improve the working conditions of human resources, increasing the overall productivity of organizations. The key-technologies in industry 4.0 hence, should promote a disruptive change also in the way ergonomics and safety risks are approached in industry. In particular, the context of Human activity recognition (HAR), which nowadays is a highly dynamic and challenging research topic, aims at determining the activities of a person or a group of persons based on sensor and/or video observation data. The underlying activity theory describes an activity as complex tasks performed by a person or a group of persons within a certain time span in a specific context. Activities are described as an aggregation of actions which in turn are understood as set of atomic steps named operations. By implementing advanced methodologies, HAR systems are able of analysing the data collected in a certain time span, and to reconstruct the activities performed from a well-defined information hierarchy of events (based on sensor inputs) fused with additional context information. Pattern Recognition, information fusion and data segmentation are the methodologies generally employed for such purpose. Recent applications of such technologies in ergonomics can be found in the scientific literature (Aiello, 2019; Akhavian and Behzadan, 2018), involving body sensors worn on different parts of the body to collect raw data of physiological signals in accordance with the body motion and transmit the data to central processing unit for activity recognition and classification. The microprocessor unit perform data mining methods and makes conclusion about the user activity (e.g. walking, sitting, etc.). For real time activity recognition system, the wearable processing unit should be fast enough to make real time decision with high accuracy. Linking the information related to the activity performed to the psycho-physical conditions of the workers could represent a disruptive innovation in the context of ergonomics. Task assignment, for example, could significantly be improved if information about the stress state of the worker could be linked to the information about how much demanding the task is. Unfortunately, although nowadays, with the diffusion of miniaturized wearable sensing devices integrated into work suits, the information about the activities can be effectively gathered, the studies on the worker's wellbeing condition assessment are generally related to the presence of some biomarkers in biological fluids. A real time assessment of the stress level would thus mean a continuous monitoring of the concentration of specific compounds in biological fluids, which is still impracticable in most cases. Such approach however less futuristic than it may seem, since the recent development of nanostructured biosensors, with unprecedented performance and miniaturization possibilities actually opens new application sceneries in such regard. Nanotechnology has sponsored the most promising upgrade on materials properties providing significant advances to overcome limitations once experienced by conventional materials. Nanomaterials are produced in the nanoscale range from 1 to 100 nm, and because of their dimension, they significantly change properties from their equivalent counterparts with structure higher than nanoscale, such as the bulk material. Notably, biosensor research is considered to be an important field since it covers a wide range of sensing capabilities, including pulse, heart rate, blood pressure, body motions, blood oxygen level, glucose, cholesterol, etc.. Used in different scientific disciplines, biosensors have been recently marketed for wellness and fitness applications. Such devices are based on the detection of a specific molecule that is linked to a health condition and can offer an actionable insight into what is happening in our bodies. In addition, such sensors can easily be integrated into workers' standard equipment employed both in indoor and outdoor operations.

In conclusion, the issues above discussed depict new sceneries in worker ergonomics and safety management systems, allowing for further methodological considerations, susceptible to be integrated by investigations, and researches. It is hence possible to foresee future developments which might significantly modify the current approach to ergonomics, including for example intelligent protection devices, integrated with workers' equipment and clothing. The introduction of IoT and smart, connected devices are now giving rise to an unprecedented level of visibility into workers' wellbeing and their environments. Intelligent gadgets (watches, helmets, vests…) continuously capture vital physical metrics like heart rate, skin temperature, movement, activity, and location. In parallel, environmental sensors record critical information about employees' working conditions and their exposure to external dangers. Exploiting such information in the context of a human-based approach to industry 4.0 will be a fundamental challenge for the next future.

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