WearRAcon Europe 2023
European Exoskeleton Conference
October 25-26, 2023

MONITOREX: ERGONOMICS AND PHYSIOLOGICAL MONITORING SYSTEM FOR EXOSKELETON USERS

Axier Ugartemendia[12], Rebeca Rico[12], Iñaki Díaz[12], Juan Martín[3]

[1]CEIT-Basque Research and Technology Alliance (BRTA), Manuel Lardizabal 15, 20018 Donostia / San Sebastián, Spain
[2]Universidad de Navarra, Tecnun, Manuel Lardizabal 13, 20018 Donostia / San Sebastián, Spain
[3]GOGOA Mobility Robots, Arzubia 10b, 7 bajo, 48220 Abadiño, Spain

ABSTRACT

Exoskeletons can contribute to decrease the incidence of musculoskeletal disorders supporting workers in heavy and non-ergonomic tasks, even if only a few prototypes effectively reached the market yet. What is missing in the commercial offer is a system that can analyze from both an ergonomic and physiological point of view the appropriate behavior of the worker wearing the exoskeleton, which is the main focus of this work. We have developed a low-cost motion capture system, combined with physiological sensors, and software able to evaluate the ergonomics and physiological condition of a user handling heavy loads and working under non-ergonomic posture. The proposed system combines both the ergonomics analysis and the physiological condition of the user to evaluate the need and proper application of exoskeletons.

Keywords: Motion Capture System, Exoskeletons, Ergonomics Analysis

1. INTRODUCTION

Exoskeletons are the maximum representative of collaborative robots as they literally wrap the human and physically collaborate with them. They are conceived to reduce the physical effort performed by users when lifting heavy loads or working under non-ergonomic postures, and thus reduce musculoskeletal injuries that are currently the first cause of work absence in the world.

As technology is evolving, exoskeletons are being introduced in industry. However, it is necessary to have the capability to evaluate the ergonomics of the exoskeleton's user, to evaluate whether the operator is in danger of having future musculoskeletal or physiological injuries [1]. What is new in our approach is the fusion of motion and physiological sensors, allowing to perform real-time integrated kinematic and physiological analysis of the ergonomics of the exoskeleton's user during physically demanding activities, with a non-invasive system, at low cost.

2. MATERIALS AND METHODS

We have developed a low-cost motion capture system for the upper-limb with 8 IMU devices (Adafruit 9-DOF BNO055) located in specific body locations (Figure 1). The information of these devices is processed by an Arduino controller (Nano 33 IoT), and the quaternions computed for each IMU device are sent wirelessly to a local computer (it could be sent to the cloud). Similarly, we use a Polar H9 Strap for physiological measures connected to the Arduino controller, and the heart rate (as pulses per minute) is also sent together with the motion information. Future developments will be compatible with smartwatch health sensors.

The new MonitorEx software gathers in real-time the information of the IMUs, computes the kinematic motion of the user with proprietary algorithms and applies a digitalized version of the well-known RULA ergonomics assessment methodology [2]. RULA outputs a numeric result, from 1 to 7, depending on the

ergonomic performance of the user. Besides, we have developed a methodology to also monitor the stress level of the user through the heart rate information acquired by the Polar sensor. The output results can be easily monitored through any device with web-browsing capabilities by using an HMI developed with Grafana.
The developed software can also be monitored in Blender 3D render engine (a virtual avatar with colored body limbs depending on the ergonomics analysis) and is compatible with FIWARE architecture. Final version of the software will be available through RAMP marketplace.

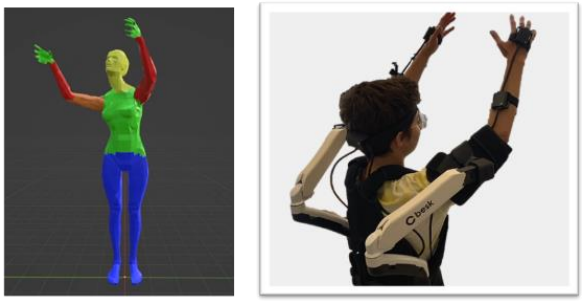

Figure 1: MonitorEx system.

3. RESULTS AND DISCUSSION

We have performed several preliminary experiments with the new system and GOGOA's BESK exoskeleton in industrial settings (Figure 2). Several workers have performed the operation of feeding a CNC machine with raw material (5 kg). We have been able to validate how the system outputs low ergonomic results in non-ergonomic postures and how the system monitors the stress level of the user as more repetitive motions are performed.

Figure 2: Preliminary experiments

Future work still needs to focus on: i) evaluating the precision of the motion capture system compared with an OptiTrack system; 2) performing motion capture also in the lower-limb; 3) enriching the physiological analysis with more sensors, preferably from smartwatches; and 4) performing extensive testing in industrial settings with several workers.

4. CONCLUSION

The main added value of the MonitorEx system and research is to enable workers and work safety responsible to evaluate the ergonomic and health condition of daily working tasks to allow taking actions before musculoskeletal or physiological disorders appear. The impact of work-related MSDs is huge both for the worker and the company. Thus, providing a tool to prevent such safety issue is of maximum value.
Another added value is related to the use and acceptance of exoskeletons in industry. Exoskeletons are designed to relieve the physical load of the task and improve workers health but wearing an exoskeleton can also be counterproductive if the user is not correctly managing the exoskeleton, or if the exoskeleton is not correctly designed. Thus, by providing a tool to validate some objective parameters regarding the performance of using an exoskeleton is of high value for their acceptance and application.

ACKNOWLEDGEMENTS

This Project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 873087.

REFERENCES

[1] Golabchi A, Chao A, Tavakoli M, "A Systematic Review of Industrial Exoskeletons for Injury Prevention: Efficacy Evaluation Metrics, Target Tasks, and Supported Body Postures," Sensors, vol. 22(7), pp. 2714, 2022.

[2] McAtamney, L, Corlett, E. N, "RULA: a survey method for the investigation of work-related upper limb disorders," Applied Ergonomics, vol. 24(2), pp. 91-99, 1993.