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Human Work Sustainability Tool

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Abstract

The work environment influences workers' well-being and contributes to the growth of personal experiences. In fact, working in an unhealthy workplace can cause stress, frustration, and anxiety. Therefore, companies have to deal with the workers' well-being in the work environment and the control and the management of human factors are crucial. In this context, the introduction of Industry 4.0 technologies can support the workplace monitoring and improvement. Some researches propose structured methods that considers several ergonomic domains together; however, it is necessary to create platforms that support data collection, elaboration, and correlation in an integrated way. Accordingly, this paper presents a tool that supports the monitoring of operators' activities and the implementation of corrective actions with the aim of making the workplace socially sustainable. Preliminary tests were conducted to assess the functionality of the tool architecture. Several use cases were simulated in laboratory with a particular focus on the framework for worker's stress detection.

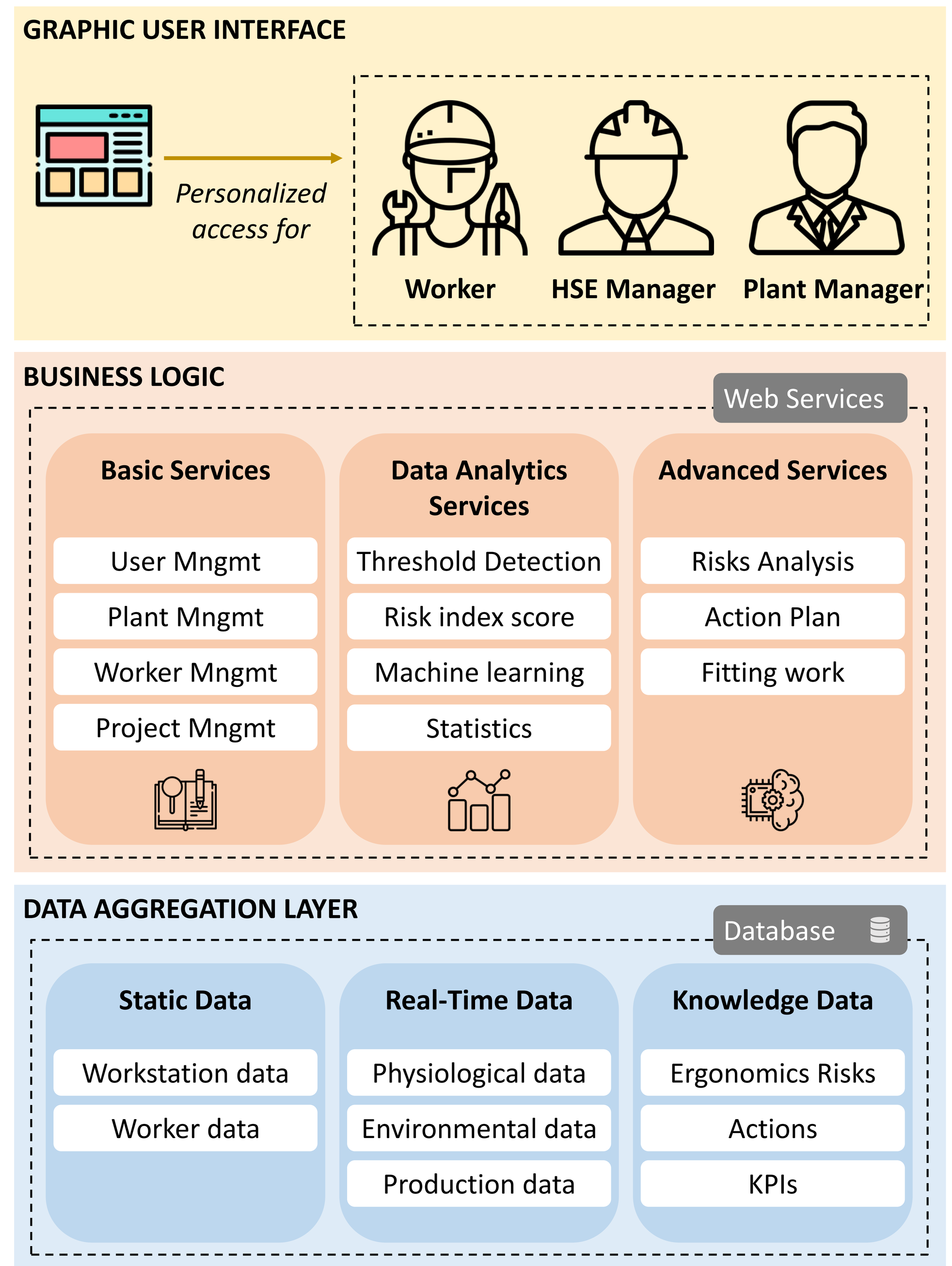
Tool architecture

Working in a healthy environment positively influences workers' well-being and contributes to the improvement of performance and productivity. Therefore the companies should achieve two goals closely related: **company performance** (e.g., productivity, quality, efficiency) and **workers satisfaction**.

This paper proposes *a tool that integrates the analysis of the operators' well-being and the working environment within the adoption of advanced digital technologies*. The idea is to integrate the analysis of the working environment and the operator's needs within a factory evolving toward the *Industry 4.0 paradigm*, in which the operator is asked for new skills and is exposed to new stressors.

The architecture is made up of three main layers:

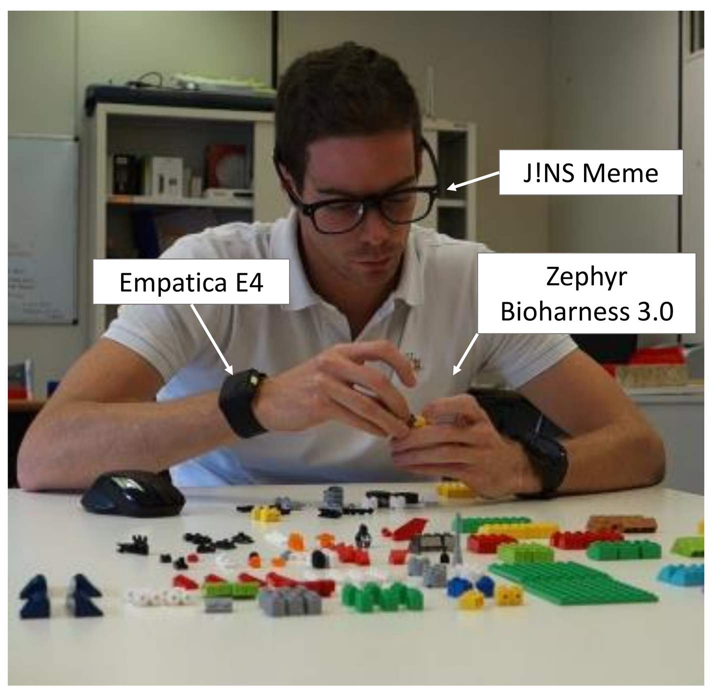
- **Data Aggregation Layer**: it contains all the data useful for the ergonomics analysis considering all its domains: physical, cognitive, organizational and environmental.
- **Business Logic Layer**: it is the core of the tool and provides all the web services, from the simple authentication to advanced data analyses. It includes:
  - *User management service*: it aims to guarantee access to the tool to users with different roles, responsibilities, and skills.
  - *Workstations and workers management services*: they allow populating and managing the related databases.
  - *Project management service*: it allows scheduling and managing the monitoring campaigns.
- **Graphic User Interface**: it is the graphic user interface that allows different stakeholders to interact with the tool. Company managers can manage the ergonomics analyses and easily elaborate and interpret the collected data. A more user-friendly interface is provided for workers, which can interact with the system to fill-in questionnaires or visualize the results related to the ergonomics of their work. The direct involvement of workers aims to favor the implementation of a participatory approach toward a win-win strategy.



Architecture of the tool for human work sustainability

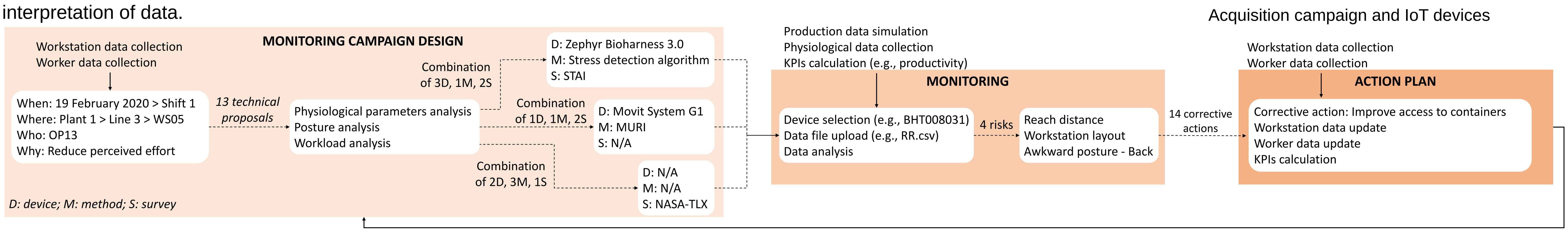
Preliminary testing of tool architecture

- **Real workflow simulation** by several use cases**:** a subset of the items suggested by the tool was selected at each step simulating a real work-flow. The preliminary results allowed optimizing the architecture, which seems to have excellent potential.
- **Machine learning-based system for workers' stress detection** consisting of three main modules:
  - *the pre-elaboration of the acquired signals*
  - *the extraction of reliable features commonly used for the stress human detection*
  - *the classification of human stress activities through a Support Vector Machine (SVM) algorithm.*
- **Acquisition campaign** performed in laboratory environment. Tasks aim to simulate manufacturing activities and they were alternating with rest periods. To calculate the performance of the system, *a cross-validation method* was adopted. The training data was split and labeled in "*no-stress*" and "*stress*" phases. The best classification results were obtained through the Gaussian Radial Basis Function kernel of SVM with an accuracy value of *93.5% ± 3.4%.*



Acquisition campaign and IoT devices

The proposed platform allows enhancing **worker's well-being** and **business performance** by a smart integration and interpretation of data.



Example of a use case simulated in laboratory

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