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MDPI

Abstract

Wearable Prototype for Smart Personal Protective Equipment †

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Abstract: Smart personal protective equipment (PPE) broadens the ways to enhance security in workplaces. Using active systems with communication capabilities, it is possible to continuously monitor workers and environmental parameters to prevent undesirable events or to quickly intervene in case of accident. This work describes the latest improvements in the design of an upgraded version of our earlier laboratory prototype. The enhancements concern a more compact form factor, reduced power consumption and replacements with the latest products available on the market. In this work, the design solution and results will be presented.

Keywords: wearable; smart personal protective equipment (PPE); safety; particulate matter (PM); gas exposure; IoT; sensor node; indoor outdoor localization

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1. Introduction

Smart PPE refers to Cyber Physical Systems which incorporate communication, elaboration, and sensing elements that are deeply intertwined to achieve a well-defined purpose. In the case of the present study, the purpose is to present a Smart PPE aimed at monitoring some parameters of the worker and of the environment to avoid non controllable or even hazardous situations. There are studies in the literature that cover the topic of the design of a Smart PPE [1–3]. Compared to the state of the art, the novelty of this work lies in the Smart PPE proposed, which finds a balance between different functionalities, dimensions, and battery endurance. This work focuses on achieving a compact and wearable form of PPE with respect to earlier versions [4,5]. Figure 1 shows the 3D rendering of the final wearable prototype and the placement of its boards.

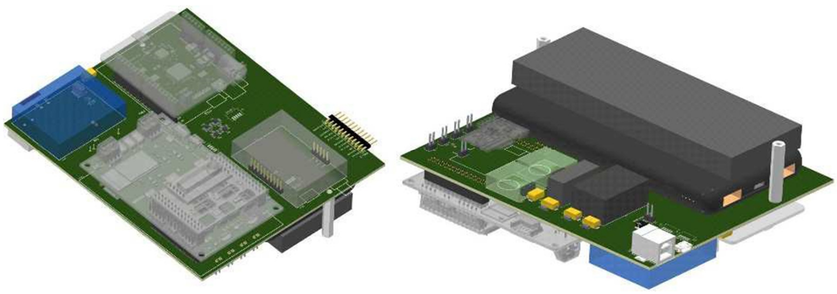

Figure 1. Naked 3D rendering of final wearable prototype based on wiring of the PCB motherboard.

Furthermore, optimizations for power consumption have been implemented to find a balance between autonomy and battery size. Additionally, improvements to the sensors have also been addressed.

2. Materials and Methods

The sensor node is composed of two boards: the Communication board and the Multi Sensor Node. The two boards operate together to ensure the correct sampling of the sensors, the elaboration of the acquired data, the encapsulation of the data in a packet that will be sent to the application responsible to show the relevant information (server LoraWan© and TagoIo cloud IoT platform). The sensor node is able to locate itself in both indoor and outdoor scenarios using an RTLS system and a GPS module, respectively. Moreover, through the motion sensor, the node can detect fall conditions of the worker. It also includes physical and chemical compound monitoring features performed by VOC, PM, CO_2, CO, and O_2 sensors. Finally, the microphone detects dangerous levels of sound pressure. The improvements made in this work mainly regard the miniaturization, based on the wiring of several PCBs on a unique motherboard, of the entire sensor node that is shown in Figure 1. The expected final dimensions of the sensor node will be about 12 cm $\times$ 16 cm $\times$ 5 cm.

Regarding power consumption optimization, selective activation techniques of the sub-devices were applied based on different events. A new sensor array design was developed to upgrade the sensors to the latest products available on the market.

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