A Cyber-Physical Model of Internet of Humans for Productivity and Worker General Welfare

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ABSTRACT

A Cyber-Physical Model of Internet of Humans (CPMIOH) is proposed in this paper. With the great advance of semiconductor technology, many wearable sensors are available nowadays. The low cost, proper accuracy, low energy consumption, and portable features of these kind sensors make a wearable device popular in recent years. Most of the applications of wearable devices are implemented in the areas of medical evaluation, clinical diagnosis, healthcare, game and entertainment, and personal fitness. However, the application in the industry is still limited. A CPMIOH is composed of wearable devices equipping on the body of workers in the factory, wireless data collecting devices, cloud data storage servers, network communication protocols, and algorithms for human movement measurement and recognition. Under this architecture, the human motion analysis is not limited in the laboratory but realized in the practical work environment. In this CPMIOH model, workers could be evaluated through continuous analysis of movement measurement and classification. The operations of a task might be reviewed repeatedly by the representation of 3D human motion model in the computer. This model also provides a potential objective analysis to complement traditional subjective evaluation methods in the ergonomic risk evaluation on the work-related musculoskeletal disorders. The biofeedback sensors also provide long-term data while the workers are exposed to the real work environment. This data assists the analysis of objective mental load in a real time. The work stress evaluation of a job would not be limited by the post subjective methods. This application would not only do benefit to monitor the stress of workers exposed to the high tension work environment but also provide an opportunity to improve the psychological health of workers by job redesign.

Keywords: Cyber-Physical Model, Internet of Humans, Internet of Things, Worker General Welfare

1. Introduction

In the manufacturing practice, people care about the productivity and efficiency of a production line, the safety of operators during work, a good and worker-friendly environment, and the health of employees. The productivity and efficiency of an operation are evaluated by reports generated from a computer system such as enterprise resource planning (ERP) and manufacturing execution system (MES). Classical management intervention is applied for the safety protection in shop floors. For some specific industry, hazardous gas detectors and thermometers are equipped in factories to monitor work environments. Ergonomics control and risk assessment are applied for the work-related musculoskeletal disorders prevention. The method of assessment of human work fatigue and risk hazard can be divided into employee’s self-assessment method, expert’s subjective observation, and objective risk factor method. The disadvantage of self-assessment is that follow-up data analyses require high technical skills. It is also difficult to interpret the data correctly. However, the problem is that there exists a great difference between workers’ experienced risk exposure and the severity of the hazardous condition. Thus, a self-assessment method may fail to produce reliable data (Viikari-Juntura et al., 1996; Balogh et al., 2004). Expert’s subjective observation and evaluation method are executed by ergonomists according to the actual situation of a work to assess a variety of pre-defined risk factors at different levels of exposure. The advantages of this kind method are low cost, a wide
range of application among varied work types, very suitable for practical investigation and evaluation. Most importantly, it will not interrupt the work. The disadvantage is that different observers might have varied judgments for the same risk exposure of work. Moreover, this method is suitable for assessment of static posture-based and/or high repeatability of movement. The objective risk factor method uses a variety of instruments to measure the magnitudes of various biomedical signals or biomechanical variables of workers at work. The advantage of this method is that you can accurately get an objective variable measurement, but the disadvantage is that the equipment is expensive, and most of the equipment will be hampered by the operation (Tong et al., 2013). As a result, such method is hard to carry out risk assessments of real works in practice.

With the progress of science and technology, the rapid advancement of semiconductor process makes the application of electronic products is extremely tiny and light. In recent years, Internet of Things (IoT) technology is getting mature; making low-cost and high reliability of wearing device is expected to become an economic and reliable new tool for ergonomic risk assessments at the workplace. This technology reveals a hope of steadying current objective risk factor methods which were difficult to implement in the workplace.

The purpose this study is to propose a Cyber-Physical Model of Internet of Humans (CPMIOH). Some electronic sensors were proposed to wear on humans, and these sensors will send information to the computer server via wireless communication technology. The proposed structure of CPMIOH is demonstrated in the next session.

2. CPMIOH Model

The analytic procedure of a CPMIOH model is illustrated in Figure 1. The CPMIOH server plays the integrated role in this model. Each worker carries sensors. Lots of data receivers are allocated in the shop floor. Workers wear the inertial and/or biofeedback sensors during working. These sensors are tiny and handy and will not obstruct the operation handling. The communication between a data receiver and a sensor could be any wireless communication protocol such as Wi-Fi, Bluetooth Low Energy (BLE), ZigBee, or any formal standardized protocol.

If there is any requirement of ergonomics investigation, the inertial and/or the bio-medical sensors are worn on the worker. The kinematics and biofeedback data are collected by the collecting device (could be the mobile phone or send to the server directly).

By the specific algorithm developed based on the criteria of the subjective evaluation methods. The tradition work related musculoskeletal disorders (WMSDs) subjective evaluation methods such as Baseline Risk Identification of Ergonomic Factors (BRIEF), Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), Key Index Method (KIM), and so on could be implemented in an objective perspective through the data generated by the inertial sensors. The physical workload would be evaluated simply by the biofeedback sensor’s data such as heart rate. While the extreme heart rate was detected during the operation, the CPMIOH server could judge if the worker was exposed under risk according to the
comparison with his maximal heart rate. Moreover, all of the data are kept for ergonomists to do advanced biomechanics and biofeedback analysis. An expert could study the work context and apply the data to develop the proper biomechanical model for a succeeding study. The heart rate based study such as heart rate variability (HRV) is possible for the mental workload of the task. Figure 2 demonstrates the data analysis procedure in a CPMIOH model as we mentioned.

3. Challenges

The technology for the services of productivity and environment monitor are mature. They could be implemented and integrated easily. However, this is not the case for the ergonomics risk evaluation services. For the ergonomics risk evaluation, many applications of inertial sensors in the clinic were reported. Medical community applied inertial sensors to evaluate the rehabilitation status and to apply in the health care like fall detection (Alvarez et al., 2016). Many researches about the body link’s orientation or angle measurement applied inertial sensors were published (Hu et al., 2014; Cockcroft et al, 2014; Lambrecht and Kirsch, 2014; Slaijpa et al., 2014; Bergamini et al., 2015; Chen et al, 2015; Ligorio and Sabatini, 2015; Ruffaldi et al, 2015). However, there is no any application in industrial practice was reported. The body movements in the industries are complex and rapid. This causes the identification of movements much harder than the limited number and expected pattern movements in most of the published literature. The need of expertise for advanced biomechanical and biofeedback analysis is another difficulty. The analysis needs more mathematical and computer programming knowledge. It might be another challenge for the developers of a CPMIOH system.

4. Conclusion

In this study, we proposed an integrated model based on wearing sensors on the person to form IoH. By this way, we could provide ergonomics risk assessment services by an objective method at the real industry shop floor. By this way, the risk assessment methods in the industry would not be limited to the subjective ones. The successful implementation of this model reveals the hope of improving workers’ welfare without losing productivity.

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