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A Novel IoT System Development of Using Wearable PPG Monitor Devices To Improve Safety Management For Shield Tunnel Construction Project.

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ABSTRACT: It is well known that construction workers have the highest rate of accident and casualty compared to other industries. This trend is similar in many other countries worldwide. In the period of 2000 to 2015, statistic shows the accident rate is still rising, specifically the tunnel construction site has a higher casualty rate among all construction sites. However, safety management has been acting as an important part in construction project management, which concerns with worker's workload and fatigue. This

research endeavors and adopts innovated senor network technologies on worker's heart rate to facilitate safety management of shield tunnel construction projects.

Heart Rate is recognized as the huam physical and psychological index to assess one's health status under clinical environment. Thanks to the micro photo-electronic technology advancing, Photoplethysmography (PPG) sensor is popularly used in healthcare and athletic training nowadays. Consumer wearable PPG devices can be seen everywhere in the public. To extend the application and added value of wearable PPG devices, a novel IoT system is developed and incorporated with bioinformatics theory. Therefore, we can continuously monitor and collect shield tunnel worker's heart rate at construction site without interfering their routine work. The first field test was taken in the April of 2018, and there were 16 volunteer workers joined the test. However, the test result was unsatisfactory. Therefore, modification of wearable PPG devices and IoT gateways were made and based on the target data-collection rate of 80%. We have increased the heart-rate detection rate of PPG devices, and increased the number IoT gateways deployed in the tunnel. As a result, we have successfully achieved 85% of the data-collection rata in the second field test taken in the October of 2018.

In this paper, we demonstrate how we design the heart rate monitor system and how we deploy BLE IoT system in the shield tunnel construction site. In order to analyze field worker's workload, we've established the standard procedure of measuring worker's Resting Heart Rate (RHR) and Working Heart Rate (WHR), which can be used as the indicators of worker's shift arrangement and workload assessment. Furthermore, each field worker's

accumulated workload can be calculated instantly by using this heart rate analytic function. It is aware that fatigue can be either endanger worker's safety or jeopardize construction progress. For further application in the safety management, we have designed a systematic method to assess and control the worker's workload, which is beneficial to optimize work shift arrangement for the shield tunnel construction projects.

Keywords: HR, PPG, RHR, WHR, Workload, BLE, IoT.