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CONCEPTION OF SMART IOL HELMET IN SMART FACTORY

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Abstract: Smart devices are coming to our world and become a part of modern life for many people regardless of gender, ethnicity, social status, and working sphere. This paper introduces the perspectives and possibilities of using Optical Wireless Communication (OWC) technology in the production field, as an element of individual protection suit. The current work investigates the use of LED light to act as a Li-Fi source to transmit and receive data. The proposed schemes of suggested device and application constellations as a part of Smart Factory are described.

Keywords: OWC, Li-Fi, Smart factory, Wearable Device, HMD, Smart Helmet

I. INTRODUCTION

Over the past forty years, wireless connectivity has turned into a necessity much like the fundamental utilities like water. Mobile devices transmitting over 600 TB of data – radio spectrum is essential for wireless communication.[1] This communication is common but has a lot of limitations not only in bandwidth but in a sphere of application. Some radio spectrums could not be used in some production fields as they can become a reason for malfunctions or production spoilage.

The opportunities of using light-emitting diode (LED) light source as the data transmitter that can be decoded with a camera or light sensor receiver is a new generation of communication sphere. Dr. Harald Haas in his "TED Global Talk" 2011 on Visible Light Communications proposed technology to overcome the radio spectrum congestion. During the presentation, Dr. Haas demonstrated his invention called "D-Light", which he also referred to as "data through illumination". Demonstrated technology, behind D-Light, showed a possibility to transfer data at speeds more than 10 Mbps using light waves from an ordinary table lamp to a nearby computer. This technology is known as Light Fidelity (Li-Fi)[2][3]. Since that time Li-Fi similar technologies are under scientific investigating in the search of the possibility of using them in practical fields.

IoT technology is increasingly being married to wearable devices to improve safety in industrial sectors including mining, oil and gas, manufacturing and transport. For example, Light reflection-based elements of suites are used in society commonly. Basic experience of using IoT, light reflection and "Smartyfication" of uniform also usable for IoL solutions to automate production through wearable protection suit elements.[4] We can add a new function to the existing things, not changing or losing the main meaning of appointment.

II. CONCEPTION OF INTERACTION WITH WORKING ENVIRONMENT

Conception of interaction with the working environment through wearable devices or gadgets is existing, but methods of interaction are different. Using visible light on the smart factories helps us to solve a number of existing problems of IoT integration to some types of activities.

First of all, we are solving all problems related to usage of electromagnetic waves. Most of the existing IoT solutions are based on using RF sensors, Zigbee, Lora, Wi-Fi and other systems that use electromagnetic waves communication principles. Yes, these methods have the right to existence, they are cheap, easy to manage and well known, which makes them really comfort to use. The attention to the RF-based systems is in priority whenever we mention about automation of working place. Nevertheless, the possibilities of using them near high-level electromagnetic engines and machinery are precarious and risky. [5, 6] As long as some of them work not properly near high intensive electromagnetic fields.

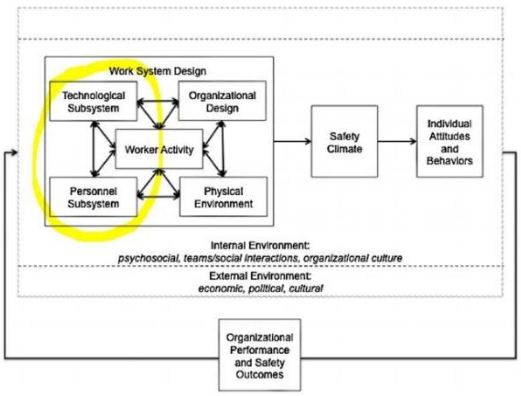

Figure.1: A conceptual model of safety; adapted from Carayon et al. (2006), Karsh et al. (2014), Hendrick and Kleiner (2001), Robertson et al. (2008), and Zohar (2010) using different systems-based and safety climate theories.[8]

Second. Using some additional smart devices in high trauma risks zones, such as areas of production with machinery, are increasing the risks for workers safety [7, 9, 10].
As it is shown in Figure.1 half of work system design is depending on Technological Subsystem and workers Personal Subsystem. Therefore, the best solution is integrating Smart modules into the safety equipment.

III. Smart Helmet Conception

According to our vision, a smart factory has to include subsystems consists of server logical level, local network and controlling elements of production line in the factory. [11, 12, 13] The system should be equipped with object and position tracking ability, as an element of worker's safety and factory security. Usually to organize control at any kind of production centres we need monitoring system to determine location of employee in the current time, his authority to be located in the particular place and permissions to exact activities. Also way to deliver operational information broadcasting (emergency, notice etc.) to the employee should be realised.
Suggested concept offers using the light sources as data transmitting devices. Particular data could be decoded by special application through smartphone camera or any other IoL device with pre-installed light sensor or camera. As the CCTV today is the demand of the time, managing of smart factories without security cameras infrastructure impractical.

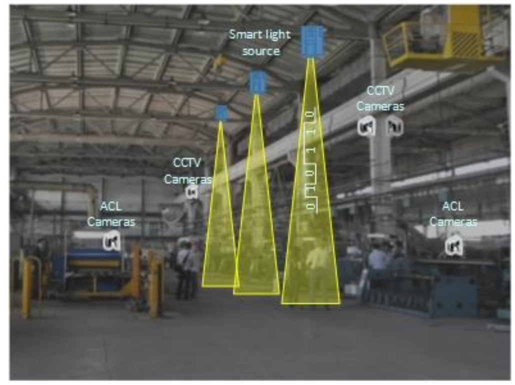

Figure 2: OWC on smart factory

Figure 2 shows conception of OWC running smart factory.
In the factory we need to integrate a communication technology into the part of the uniform that always on worker as a safety element. [7]
The idea of using a smart helmet in production field is not brand new. For many production fields academicals and practical researches are already worked on the same. Smart helmet is offered as the personal worker wearable IoT uniform element before.[15, 16, 17] Nonetheless the suggested in this paper smart helmet solution, implies using light sources, as data transmitting and light sensors as data receiving elements. A smart helmet is offered as workers personal device. This device can send data through the helmet-torch and receiving data through light sensors or built-in camera. In addition, it has an earphones through which the worker can hear broadcasting information.

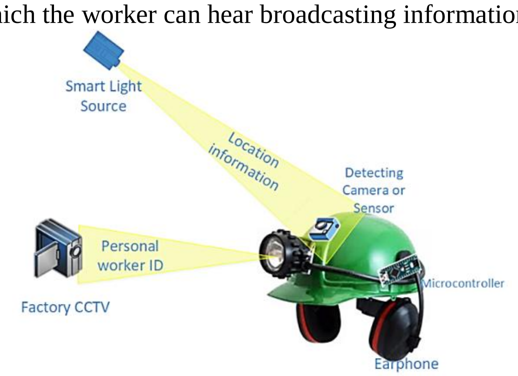

Figure.3: Smart Helmet

These applications are realizing the communication between smart factory working space and worker, without using any RF data transceivers and cooperate with the smart factory security system. Figure 3.
Generation of location information organized on micro-controllers base that installed in smart light source devices. The same conception is used to organize workers' personal ID data transmitting torchlight.
It is possible to organize high-speed real-time data broadcasting through light sources [2, 3], but considering the fact that workers during their activities are moving and change position around the factory, full information real-

time broadcasting is not so effective. Much more efficiency can be earned by using short commands transmission. All required information should be pre-written inside a smart helmet and just called by special commands, which are transmitted by light sensors.

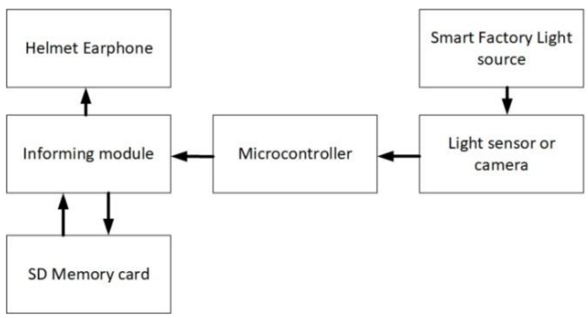

Figure 4: Smart helmet informing system work block diagram

IV. TECHNICAL SOLUTION

For the laboratory prototype, the Arduino Nano microcontroller isused. The Arduino Nano was chosen as the easiest way for forming dimming communication signal through PWM, and for its small size could be easily installed into the helmet. [17]

DF Player Mini module is a serial MP3 module that provides the perfect integrated MP3, WMV hardware decoding. Through simple serial commands this module allows to specify audio record play, as well as how to play record and other functions, without the cumbersome underlying operating. This module allows connecting up to 3W speakers without amplification. Files structure system also should be planned and organized properly, according to the required parameters of the smart factory.[18]

For the personal torchlight on the helmet in solution we chosefull color LED. It has a good response - “high” timing is 440 ns. The PWM generated from Arduino is used to control the SK6812 LED chip addressing. The PWM frequency of the SK6812 is more than twice as high as that of the WS2812 (1.1 kHz vs. 430 Hz). In SK6812 control of four LEDs requires 32 bits and differs locks of color.[19]

For light source sensor simple photoresistor was taken.

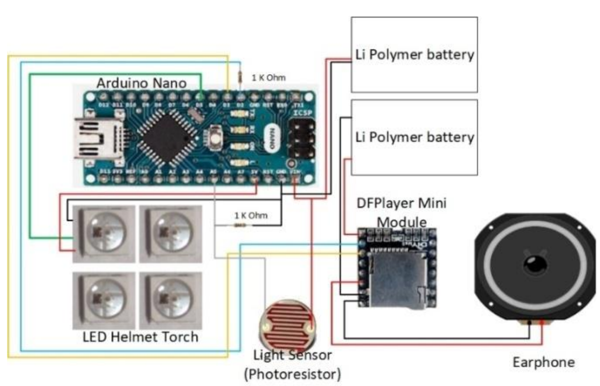

Figure.5 Smart helmet hardware prototype

V. SUGGESTED APPLICATIONS

A. *Integrated Personal Worker ID Subsystem*

Many types of ID systems are used as personal worker key that allows admission to work. Unfortunately, not all types can be used in production halls. Since commonly used ID systems are based on RFID systems, barcode systems or smartphone identification systems, the practice of using any of them in real factories is very doubtful.

RFID systems are weak in using near high intensity magnetic fields, which are common near any production machine that has simple electro-magnetic engine. Using fingerprint access systems are not applicable because workers are usually wear gloves or/and their hands can be in lubricant or wet. In case of other biological ID systems, like an eye scanner - workers have to use glasses and the sensor has no reasonable price. In case of using machines with rotating or moving mechanisms, using barcode cards or mobile devices is extremely dangerous. Usually employee wearing his ID card on the neck can be a reason of accident in case of getting this neck badge into the engine. Same is for mobile device, if this device enters the moving part of the operating mechanism, it may cause a serious malfunction or an accident.[4]

Smart helmet solution helps to reach required security level in workers' identification. Light-based ID data transmitted by torch on the helmet is controlled by centralized Factory Security system or locally. Integrated access control system, decides to grant access to the worker to a production machine or working zone, or denies it according to the access control list (ACL).

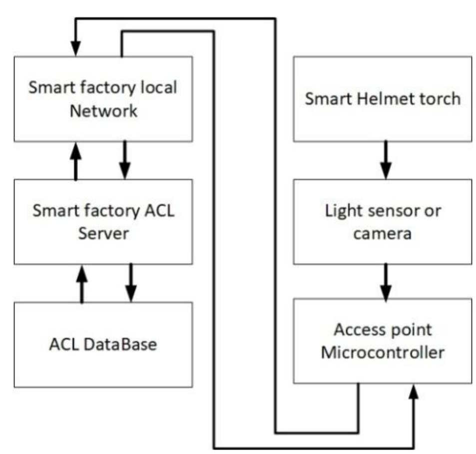

Figure.6 Smart factory ACL based security system Block diagram

In case of using camera based receiver Factory administration getting more operative data about current condition of employee and production machine in real time mode.

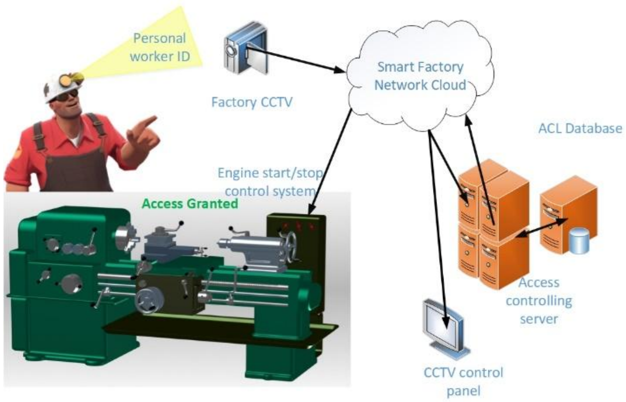

Figure.7 Smart factory system use case diagram

This grants more confidence in safety for employees and administration.

Figure.7 shows an example of a complex method of smart helmets work as a part of a smart factory system. When a worker wants to start the engine of a machine, he needs to send data from his personal torch to the CCTV camera that installed near. Through the local network, this information is coming to the CCTV control panel and the Access Controlling Server. After checking permissions in ACL database, access controlling server sending unlocking message to the engine start/stop control system that built-in to machine allowing the employee to start working process. The important point of this solution in double security control, which is provided by security officers through CCTV control, and smart factory access controlling server.

B. Emergency Case Supporting System

In case of emergency, through changing of the lighting system on Smart factory into Alarm mode (red color or dark orange color) the Smart helmet system obtains information about the closest evacuationpath, and informs workers through earphones. This option is technically allowed by using camera sensors or adding color recognizing sensors as well as getting simple OOK command.

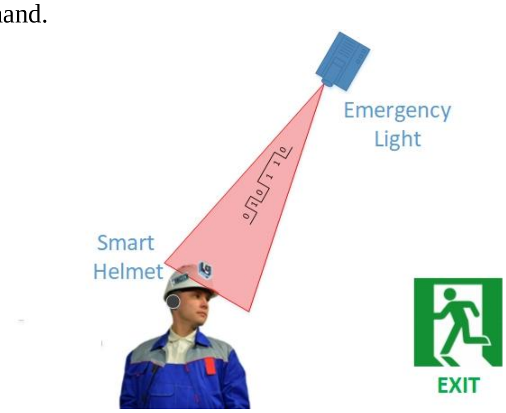

Figure.8 Emergency supporting system use case

This system can be used, as a part of a worker's personal security system. After camera detects color changing, it proceed an algorithm of self position defining.

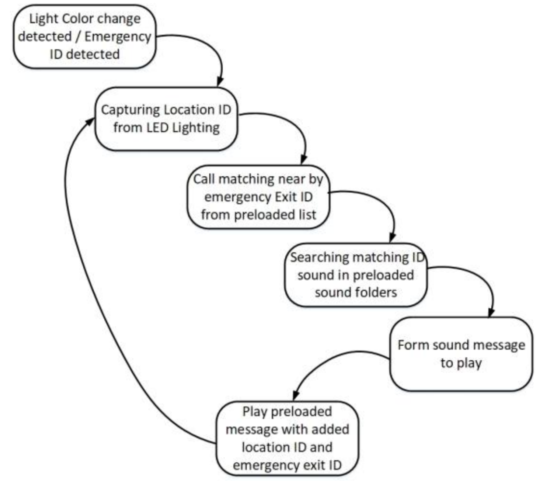

Figure 9.State Diagram of Smart helmet location defining algorithm

Based on the location information captured from lighting bulb, smart helmet system informs the worker about the nearest emergency exit from the factory. Information kept in the SD card and just called by a command received from an emergency light source. All this information is preloaded inside the smart helmet navigation system, based on the possibility of using a smart factory lighting systemin navigation. [20,21] This solution helps to avoid problems with communication between smart helmet and security system due to smart factory infrastructure continuously sending only one type of data - ID of audio tracks to play in headphones.

VI. Conclusion

Current work did suggest using a head-mountable device based on Li-Fi communication in a factory environment. As a part of Smart Factory conception, this work is described a positive opportunity of using safe communication between workers and infrastructure. The laboratory experiments showed exact results, which are described above.

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References

[1] SreeshaDamodaran, Talal Shaikh, Prof. Nicholas K Taylor, “Using Mobile Phone Based Camera To Read Information From A Li-Fi Source”,21st International Conference on Engineering of Complex Computer Systems, Dubai, UAE,2016,pp 165-170.

[2] Sharma, V., Exploring Visible Spectrum: A Study Of Light Fidelity System and Its Applications, International Journal of Enhanced Research in Science Technology and Engineering, 3(5), India, 2014, pp.349-350.

[3] Dobroslav Tsonev, Stefan Videv, and Harald Haas "Light fidelity (Li-Fi): towards all-optical networking", Proc. SPIE 9007,

Broadband Access Communication Technologies VIII, 900702 (1 February 2014); https://doi.org/10.1117/12.2044649.

[4] C. Musu, V. Popescu and D. Giusto, "Workplace safety monitoring using RFID sensors," 2014 22nd Telecommunications Forum Telfor (TELFOR), Belgrade, 2014, pp. 656-659. doi: 10.1109/TELFOR.2014.7034494

[5] M. Hutter, M. Schmidt, T. Plos . RFID and its Vulnerability to Faults. International Workshop on Cryptographic Hardware and Embedded Systems - CHES 2008, Washington, USA, August 10-13, 2008, pp 363-379.

[6] Huo, Y., & Jia, F. (Eds.) (2008). Supply Chain. The Way to Flat Organisation. Vienna, Austria: I-Tech. doi:10.1201/9781420052824.

[7] Sanguk Han, Farzaneh Saba, Sang Hyun Lee,Yasser Mohamed, Feniosky Pena-Mora, Toward an understanding of the impact of production pressure on safety performance in construction operations, Accident Analysis and Prevention, Vol. 68, ISSN: 0001-4575, 2014, pp.106–116.

[8] Lauren A. Murphya, Michelle M. Robertson, Pascale Carayon, The next generation of macroergonomics: Integrating safety climate. Accident Analysis and Prevention, Vol. 68, ISSN: 0001-4575, 2014, pp.16–24.

[9] Jan K. Wachter, Patrick L. Yorio, A system of safety management practices and worker engagement for redducing and preventing accidents: An empirical and theoretical investigation. Accident Analysis and Prevention,Vol. 68, ISSN: 0001-4575, 2014, pp.117–130.

[10] B. Lewczuk, G. Redlarski, A. Zak, N. Ziólkowska, B. Przybylska-Gornowicz, M. Krawczuk. Influence of Electric, Magnetic, and Electromagnetic Fields on the Circadian System: Current Stage of Knowledge. Hindawi Publishing Corporation, BioMed Research International, Volume 2014, ISSN: 2314-6133, 2014.

[11] D. Zhang, J. Wan, C. Hsien and A. Rayes, Industrial Technologies and Applications for the Internet of Things, Computer Networks, vol. 101, 2016, pp.1-4. https://doi.org/10.1016/j.comnet.2016.02.019Z.

[12] Shu, J. Wan, D. Zhang and D. Li, Cloud-integrated Cyber-Physical Systems for Complex Industrial Applications, Mobile Networks and Applications, Vol. 21, No. 5, Springer-Verlag New York, Inc. Secaucus, NJ, USA2016, pp.865-878.

[13] B. Chen, J. Wan, L. Shu, P. Li, M. Mukherjee and B. Yin, "Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges," in *IEEE Access*, vol. 6, pp. 6505-6519, 2018. doi: 10.1109/ACCESS.2017.2783682.

[14] P. Hazarika, "Implementation of smart safety helmet for coal mine workers," 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), Delhi, 2016, pp. 1-3. doi: 10.1109/ICPEICES.2016.7853311.

[15] Muthiah M, Aswin Natesh V and Sathiendran R K, "Smart helmets for automatic control of headlamps," 2015 International Conference on Smart Sensors and Systems (IC-SSS), Bangalore, 2015, pp. 1-4. doi: 10.1109/SMARTSENS.2015.7873589.

[16] S. S., "Smart Helmet Using RF and WSN Technology for Underground Mines Safety," 2014 International Conference on Intelligent Computing Applications, Coimbatore, 2014, pp. 305-309. doi: 10.1109/ICICA.2014.105.

[17] Arduino nano 3.1 Technical Data Sheet.https://www.es.co.th/Schemetic/PDF/ARMB-0022.PDF(Accessed15 November 2019)

[18] DF Player Mini module Technical Data Sheet.http://www.picaxe.com/docs/spe033.pdf(Accessed 15 November 2019)

[19] LED COLOR SK6812 Technical Data Sheet.https://cdn-shop.adafruit.com/product-files/1138/SK6812+LED+datasheet+.pdf(Accessed 15 November 2019)

[20] C. Rizos, G. Roberts, J. Barnes and N. Gambale, "Experimental results of Locata: A high accuracy indoor positioning system," 2010 International Conference on Indoor Positioning and Indoor Navigation, Zurich, 2010, pp. 1-7. doi: 10.1109/IPIN.2010.5647717.

[21] D. Namiot, On indoor positioning, International Journal of Open Information Technologies, ISSN: 2307-8162, vol. 3(3), Moscow, RF, 2015, pp. 23–26.

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