Study on the Possibility of Advancement for Shipyard Workplace Safety Management System Using Drone Images

Yoonsook Hwang, Woo-Sung Jung, Dae Seung Yoo
Mobility Robot Research Division
Superintelligence Creative Research Laboratory
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
{hanulai403, woosung, ooseyds}@etri.re.kr

***Abstract*—The work site of the shipbuilding industry not only has a high possibility of various types of accidents, but also has a high possibility of leading to a major accident. Therefore, various attempts are being made from all of society including companies and academia in order to identify the cause of the accident at the shipyard work site and respond appropriately to it. As an example, we are developing a safety management system that can use drones based on 5G communication to acquire a wide range of images in the shipyard workplace, analyze data with AI, and respond immediately if necessary. However, AI, which has made great progress in recent years, has some limitations compared to human cognitive characteristics. Therefore, we would suggest the variables worth considering such as cognitive style that can be to the advanced safety management system in the shipyard workplace by utilizing the advantages of data collected using 5G communication-based drones and supplementing the limitations of AI.**

***Index Terms*—worker, safety, risk, prediction, shipyard**

I. Introduction

Korea had shown the achievement of reducing the rate of death per 10,000 workers in 2021(0.43 per 10,000 employees) by 1/3 compared to that in 2001(1.23 per 10,000 employees) through efforts in various fields of society such as development of economy and technology, policy efforts and improvement of safety awareness, etc. However, Korea's scale of serious accidents is still low, ranking 34th out of 38 OECD countries [1]. In addition, as a result of estimating the amount of direct and indirect economic losses due to industrial accidents, using Heinrich's calculation method on casualty losses, the figures in Korea showed an increasing trend from about 17 trillion won (2009) to about 25 trillion won (2018) [2]. This tendency was similar to the estimated amount of economic loss by year which was estimated by the Ministry of Employment and Labor (MOEL), and it shows a continuous increasing trend after 2019 shown Fig.1 [3]. It means that this as a situation that requires transformation into an industrial safety country. Therefore, the MOEL had released a "Serious Accidents Reduction Roadmap to Leap forward as an Industrial Safety Advanced Country" that includes the goal of reducing the rate of death per 10,000 workers to the average level (0.29 per 10,000 employees) of OECD countries by 2026 [1].

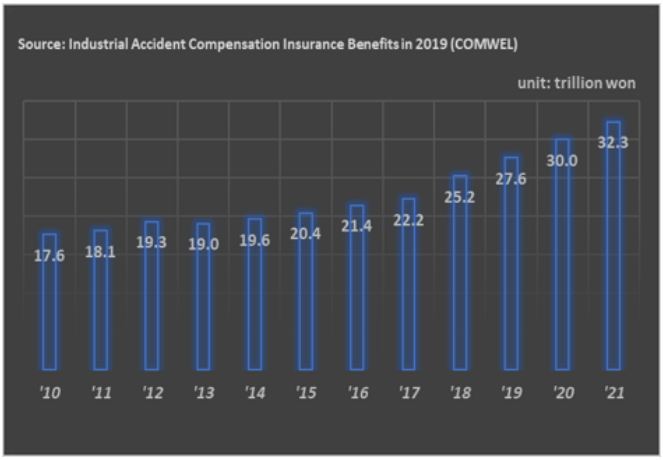


Fig. 1. Amount of Economic Loss due to Industrial Accidents by the MOEL

II. 5G-based Sipyard Workplace Safety Management System

We confirmed that, in Korea, both the number of injured and the number of deaths in the "ship building and repair industry", which constitutes the manufacturing industry, increased compared to the previous year (as of the end of Dec. 2022) through by checking the status of the top subcategories with frequent disasters by major industries (Table I). In addition, both the accident rate (2.61%) and the rate of death (3.68 per 10,000 workers) of the "ship building and repair industry" were higher than those of the "manufacturing industry (respectively, 0.79% and 1.27 per 10,000 workers)" [4]. It is a result that can be guessed right from the fact that the US Department of Labor defines "the work" as one of the three most dangerous industries [5]. And the shipbuilding industry from the perspective of the probability of occurrence of safety accidents is an industry in which various types of man-made accidents can occur compared to other industries. It is because most of the work done at that workplace is labor-intensive and requires highly specialized skills [6].

Therefore, various attempts are being made in all of society

TABLE I
TABLE I. THE NUMBER OF INJURED AND DEATHS IN THE "SHIP BUILDING AND REPAIR INDUSTRY"

	2021	2022
The number of Injured	3,125	3,336
The number of Deaths	40	47

including companies and academia for identifying the causes of various types of safety accidents at shipyard work in place and to respond appropriately to them.

Drones are an absolutely necessary equipment in the field of maritime where has to perform various tasks as follows: the task of inspecting super-large port equipment in ports that are difficult for workers to access, the task of inspecting gas and risk in ships with risks, the high cost-tasks such as surveying the aerial or cleaning the underwater ship, and the task of searching the sea with a radius of more than 10km [7]. In addition, there is also a study on that presented an improved adaptive convex-combination method that performs better in accurate channel estimation, which is essential in UWC (Underwater Communication) that is commonly used in coastal surveillance and early warning systems [8].

However, the safety management system that is currently used or available at the shipyard site has a limitation in that it is difficult to transmit the necessary images for safety inspection in real time due to the nature of the field using a communication method with limitations in communication distance. For example, considering the case of using a drone to acquire images, transmit data, and then respond appropriately using an RF communication method which it is available distance within 1km, therefore the drone flight is possible only within that range. And as a result, the ability to respond to violations of safety rules in real time (work at high places, wearing/not wearing safety helmets, etc.) is inevitably limited.

The limitations can be partially overcome at work sites where 5G communication is available. It can be expected that

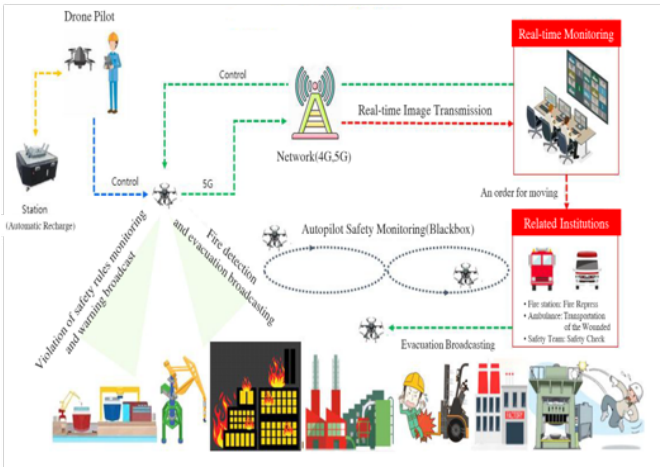
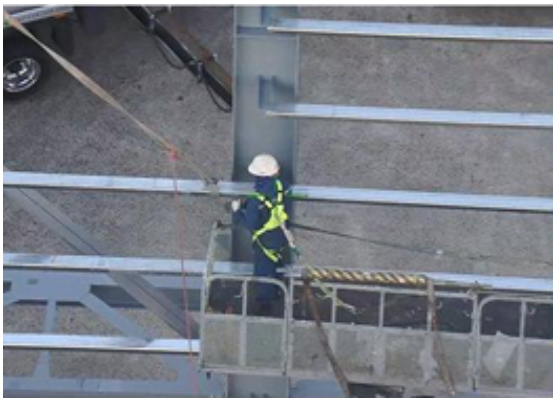
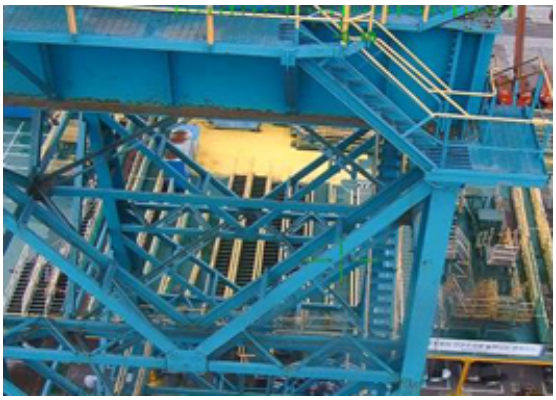


Fig. 2. Conceptual Diagram of Safety Inspection using 5G communication and Drones

(a) check the tetrapod



(b) check the new shelter work at heights)



(c) check the cranes at high places

Fig. 3. Inspection of Dangerous Areas using Drones

the drone flight distance can be expanded to more than 10 km, therefore the safety inspection area can be expanded and immediate responses to the safety rule violations can be made possible, is developing "5G-based Safety Management System using the Drone" (Fig. 2). It is possible to remotely inspect loss areas and conditions on breakwaters or tetrapod that are dangerous work for workers to perform, inspect new shelter work at height and crane height area, etc. It is also possible to integrated monitoring the entire shipyard worksite and the data collected through monitoring is the foundation of artificial intelligence analysis (Fig. 3) [9].

In other words, it is expected that data collected through integrated monitoring of shipyards based on 5G communication will create new value in terms of managing workplace safety using AI.

III. A Proposal for Developing Better Safety Management System

AI has made great strides in recent years. However, it still has the following limitations are compared to cognitive science, which seeks to understand the nature of cognition and behavior of human [10].

- (Narrow focus) Difficulty generalizing to new situations and contexts
- (Lack of creativity) Lack of the human thinking (creativity and originality) not generation of new ideas and solutions
- (Limited understanding of context) Difficulty understanding the broader context of a problem or situation (which can lead to errors and misunderstandings)
- (Limited social and emotional intelligence) Lack of the deep understanding and empathy which human being possession

In addition, since most of the development of artificial intelligence is based on brain cognition and it cannot simulate changes in subjective emotions and mental states of human. Therefore, there is a study referring that the direction of developing an artificial intelligence system combined with cognitive psychology is the research direction that artificial intelligence research should pursue [11].

In the R&D development prospects of Korea for image analysis technology, which analysis on spatial-temporal relationship, the following blueprint was prepared to secure technology that overcomes the above limitations [12].

- Short Term(2020 2022): Development of image analysis technology without temporal-spatial context (recognizing objects, people, and backgrounds separately)
- Medium Term(2023 2026): Development of analysis technology that considers piecemeal temporal-spatial correlation (recognition by piecemeal analyzing temporal or spatial correlations of objects, characters, and backgrounds)
- Long Term(2027 2030): Development of technology that comprehensively analyzes temporal-spatial correlations (recognition by comprehensively analyzing temporal or spatial correlations of objects, characters, and backgrounds)

A new method, which combines all color, texture, and both local and global characteristics of shape in content-based image retrieval, was proposed based on the fact that these features serve as important information when humans has recognized images. As a result, the accuracy performance was better than existing methods [13]. Among other human factors, cognitive style is an individual variable that consistently appears in the way information is collected, processed, and organized [14], and affects decision-making or thinking processes when faced with new information, situations, or problems [15], [16]. In addition to this, the cognitive style affects the perceiving and processing of the information when acquiring information through observational behavior [17]. The types of cognition styles are variously classified according to researchers, such as reflectivity-impulsivity style [18], field dependence-independence style [19], diverging-converging style etc. [20]. It would be adaptive to have a flexible judgement that it can vary according to the characteristics of the situation, in such a classification, rather than judging that a particular style is superior to another style. Therefore, if the cognitive style of human is considered on the understanding the context of problems or situations, it is possible to create more rich values.

Researchers will be able to overcome the limitations of current AI described above by combining AI with an understanding of cognitive science. In other words, the combination of the two research fields will enable the developing of effective intelligent systems that perform tasks in a more human-like way than before [10].

In this project, the image information collected by using drones based on 5G communication has the advantage of being non-contact to workers and enabling image collection including various information in a wider area in shipyard site. Based on this image information, it will be possible to analyze advanced AI considering the context of the shipyard workplace (environmental context) and the relationship with other workers (social context). Furthermore, it is expected that safety system advancement will be possible if it can be selectively applied the system that appropriate cognitive styles for each workplace or situation.

Acknowledgments

This work was supported by Institute of Information & Communication Technology Planning & Evaluation(IITP) grant funded by the Korea government(MSIT) (2020-0-00869, Development of 5G-based Shipbuilding & Marine Smart Communication Platform and Convergence Service)

References

[1] MOEL, "Serious accidents reduction roadmap to leap forward as an industrial safety advanced country," 2022.
[2] KOSHA, "A comparative analysis of changing trends in occupational accident rate among major countries," 2020.
[3] MOEL. (2023) e-employment and labor indicator: Estimated amount of economic loss due to industrial accident,. [Online]. Available: http://eboard.moel.go.kr/indicator/detail?menu_idx=47
[4] ——, "Analysis data of industrial accidents in korea in 2022," 2023.
[5] U. BLS. Statistical data of shipbuilding industrial disaster. [Online]. Available: http://www.bls.gov/iif/
[6] J. H. Woo, "Research on the hse application with smart device and biometrics," *Korean Journal of Computational Design and Engineering*, vol. 19, no. 2, pp. 157–168, 2014.
[7] KMI, "A study on establishment of roadmap using the drone of ocean & fisheries," March 2017.
[8] A. Kumar and P. Kumar, "An improved sparsity-aware normalized least-mean-square scheme for underwater communication," *ETRI Journal*, vol. 45, no. 3, pp. 379–393, 2023.
[9] ETRI, "Research performance report(2nd year) of development of 5g-based shipbuilding & marine smart communication platform and convergence service," 2022.

[10] K. Gülen. Two sides of the same coin: Understanding ai and cognitive science, artificial intelligence and cognitive science are two related but distinct fields that seek to understand and replicate intelligent behavior., in artificial intelligence, data science. [Online]. Available: https://dataconomy.com/2023/04/12/artificial-intelligence-vs-cognitive-science
[11] J. Zhao, M. Wu, L. Zhou, X. Wang, and J. Jia, "Cognitive psychology-based artificial intelligence review," *Frontiers in Neuroscience*, vol. 16, p. 1024316, 2022.
[12] IITP, "A blueprint for artificial intelligence technology by 2030," 2020.
[13] H. H. Bu, N. C. Kim, and S. H. Kim, "Content-based image retrieval using a fusion of global and local features," *ETRI Journal*, 2023.
[14] D. H. Jonassen, "Cognitive styles/controls and media," *Educational Technology*, vol. 19, no. 6, pp. 28–32, 1979.
[15] R. Riding and I. Cheema, "Cognitive styles—an overview and integration," *Educational psychology*, vol. 11, no. 3-4, pp. 193–215, 1991.
[16] R. Riding and S. Rayner, *Cognitive styles and learning strategies: Understanding style differences in learning and behavior*. Routledge, 2013.
[17] S. Messick, "The nature of cognitive styles: Problems and promise in educational practice," *Educational psychologist*, vol. 19, no. 2, pp. 59–74, 1984.
[18] J. Kagan, "Individual differences in the resolution of response uncertainty." *Journal of Personality and Social Psychology*, vol. 2, no. 2, p. 154, 1965.
[19] H. A. Witkin, R. B. Dyk, H. Fattuson, D. R. Goodenough, and S. A. Karp, "Psychological differentiation: Studies of development." 1962.
[20] L. Hudson, *Contrary imaginations*. Harmondsworth: Penguin, 1966.