Geospatial Intelligence for Health and Productivity Management in Japanese Restaurants and Other Industries

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Abstract. Health and Productivity Management (HPM) requires simultaneous improvement of labor productivity and Quality of Working (QoW), which consists of health, workability, and rewarding. In order to deal with a wide range of issues for HPM, engineering approaches are much more effective rather than just relying on experience and intuition. First, this paper outlines Geospatial Intelligence (GSI) as a tool for such engineering approaches, which supports problem solving by linking geospatial data with other data. Next, we summarize use cases of GSI in service and manufacturing sites, including Japanese restaurants, which have addressed labor productivity and QoW. Finally, we extract the metrics regarding labor productivity and QoW used in those use cases.

Keywords: Health and productivity management (HPM), Geospatial intelligence (GSI), Quality of working (QoW), Indoor positioning

1 Introduction

In 2015, SDGs were adopted by the United Nations, and in the same year, the Ministry of Economy, Trade and Industry (METI) and the Tokyo Stock Exchange (TSE) started to select HPM stocks in Japan. HPM requires the simultaneous improvement of labor productivity and QoW [1]. As shown in Fig. 1, QoW consists of health, workability, and rewarding, which is closely related to occupational safety and health, QWL, and decent work, as well as social capital. To improve both labor productivity and QoW in a well-balanced manner, it is necessary to deal with a wide range of issues. Therefore, there is limitation in taking action by experience and intuition, and engineering approaches are essential.

2 Geospatial Intelligence

It is natural to incorporate ideas such as digital twin and DX as engineering approaches that contribute to HPM. An effective tool for this purpose is GSI, which supports problem solving by linking geospatial data, including positioning data, with other

sources of data. This is often described as GEOINT, but it has a strong national security nuance, so here we call it GSI. The conceptual diagram of GSI is shown in Fig. 2 [2].

GSI makes organic use of both (1) digital twin/IoT/IoH technologies and methodologies and (2) social technologies and methodologies cultivated in service engineering, IE, etc. to provide a comprehensive picture of the current situation in service and manufacturing sites while acquiring 6M data there. Furthermore, GSI can support process modelling, improvement activities, and preliminary evaluation (simulation). It has been reported that about 60-80% of data is related to location [3], and that humans spend about 90% of their time indoors [4]. In light of these facts, we believe that GSI, especially Indoor GSI is an effective way to promote DX (Fig. 1).

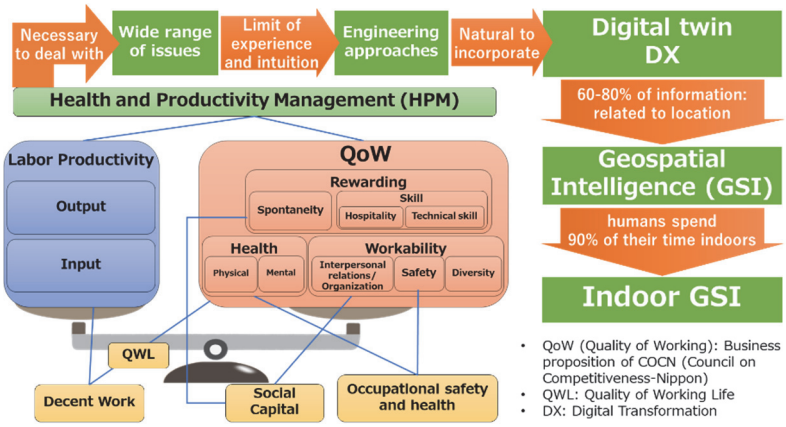

Fig. 1. Health and Productivity management (Labor productivity and QoW).

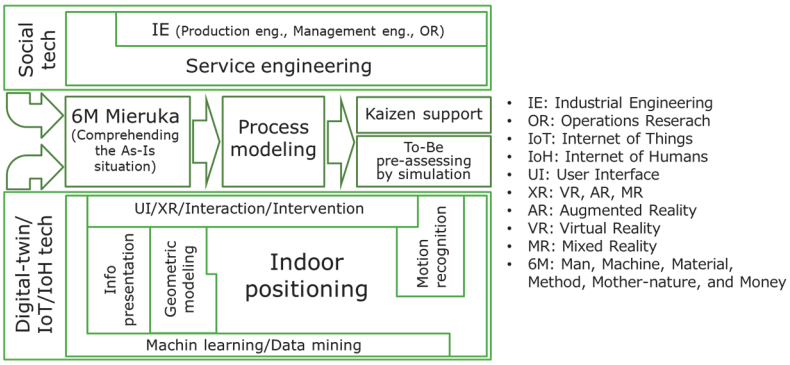

Fig. 2. Conceptual diagram of GSI.

3 Use cases of GSI

Tables 1 and 2 aggregate the use cases of GSI in service and manufacturing sites, including Japanese restaurants, that AIST has been involved in or investigated. As

shown in the tables, both of productivity and QoW have been addressed in most of the cases. Although we have started applied GSI with a clear awareness of QoW and HPM only since 2015, it is confirmed that both productivity and QoW have been targeted since 2010 when we started applying GSI for 'Kaizen (improvement)'. Table 1 lists the objectives, methods, effects and results, positioning technologies used, joint research partners, investigation sites, and references for each case study, and each row of Table 2 presents the evaluation items, indicators, and contents related to labor productivity and QoW used for each case in the same row of Table 1.

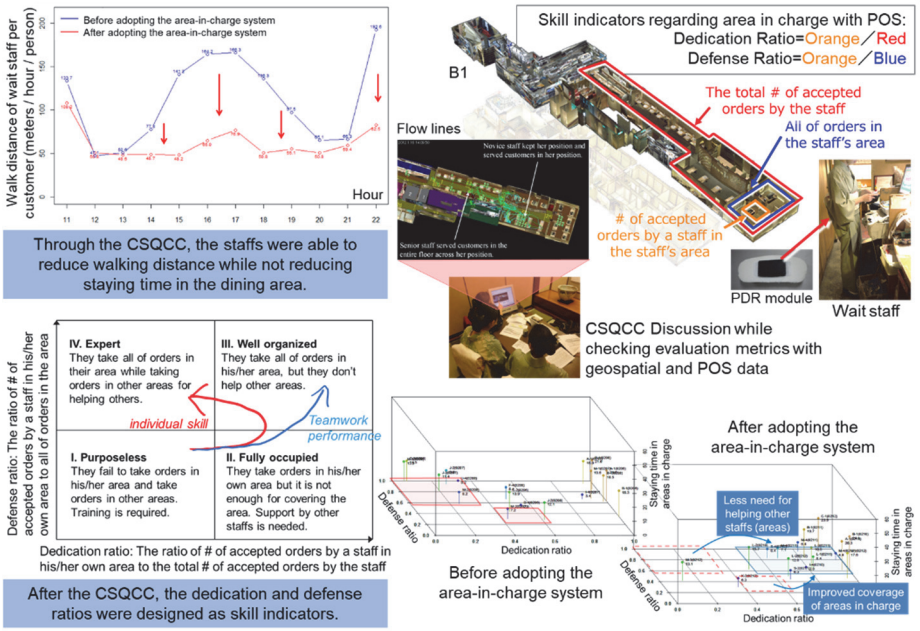

Fig. 3. Example of CQSCC with GSI in a Japanese restaurant in 2012.

The sites and job categories covered include helpers and nurses at nursing homes [6], guest room attendants at Japanese inns [7], customer service assistants and catering staff at Japanese restaurants [8-11], flight attendants on passenger planes [12], building maintenance workers [13], pickers at distribution warehouses [14], office workers, and manufacturing workers at cable factories [2][15]. Over the years, especially through practical experiments in Japanese restaurants, GSI-related techniques and methodologies have been developed and improved, and knowledge has been accumulated [8-11]. In addition, in the past few years, we have confirmed that the technologies, methodologies, and knowledge can be transferred from the service sites to the manufacturing sites [2][15].

As an example of GSI utilization, we briefly present a case study of a Japanese restaurant in 2012 [9] along with each item in Tables 1 and 2 (Fig. 3). The purpose of using GSI in this case was to reduce the physical workload of the employees while maintaining hospitality, which had been improved in the previous year [8]. In order to

achieve this goal, a CSQCC (Computer Supported Quality Control Circle) activity [8] was conducted by measuring flow lines, analyzing descriptive statistics of each indicator, and visualizing them. For measuring flow lines, the CSQCC installed an integrated indoor positioning system based on PDR, active RFID, and map matching. It was proposed spontaneously by the CSQCC participants to adopt an area-in-charge system, and it resulted in a shorter walking distance while maintaining hospitality.

In addition, as a spinoff effect of adopting the area-in-charge system, skill indicators for individuals and teams were designed as in the dedication and defense ratios (precision and recall in [9]) regarding the area in charge. These indicators were derived from POS (Point of Sales) data, and it allowed us to visualize the distribution of the skills of each wait staff. Thus, it can be seen that productivity (waste), health (physical load), rewarding (hospitality skills, spontaneity), and workability (information sharing, transparency of work conditions) were efficiently and simultaneously handled by GSI in this case study.

4 Summary of use cases

The purposes of each case have progressed from understanding the current (As-Is) situation alone to supporting improvement and pre-assessing (To-Be) hypotheses by simulations. In addition, the specific objectives have become broader such as skill analysis, training support, simultaneous support for productivity improvement, safety management, and health management, effect verification of introducing robots, and feasibility verification of employment support for the visually impaired (Fig. 4).

In some cases, existing indicators can be applied, while in other cases, the process starts with designing indicators. The evaluation items {indicators} for labor productivity include those that can be obtained directly from geospatial data, such as wasted movement {flow lines}, traffic congestion {heat maps indicating duration of stay}, and deviation from code of operation {duration of stay in each area}; those that can be applied indirectly from geospatial data, such as workload and working hours; and other items (number of additional orders {POS}, service quality {customer complaints}, added value {operating profit (rate)}, and labor productivity {sales per hour}) are used (Fig. 5).

As described above, QoW consists of health, workability, and rewarding. Regarding health, the walking distance is used for both the negative aspect of physical load and the health-promoting aspect of exercise intensity, and geospatial data is also applied to the evaluation of exercise space usage rate {duration of stay in the area} and mental load {relaxation/contingency allowance}. As for rewarding, individual and team skills are evaluated based on the flow lines, movement speed, duration of stay, working hours, or the dedication/defense ratio in charge. For qualitative evaluation of skills by retrospective interviews, pseudo FPV (First-Person View) videos generated with 3D models of work sites and flow lines [5] are sometimes used as visual geospatial contents.

And with respect to interpersonal relations and organization out of workability, it is confirmed whether information sharing, transparency of work conditions, and

visualization of the 6M data have been carried out, and geospatial data such as flow lines and heat maps are used as contents for this purpose. Other evaluation items for interpersonal relations and organization include fairness {unevenness of workload among workers}, descriptive statistics of communication {flow lines and duration of stay}, and Employee Satisfaction (ES) {questionnaire}. Flow lines and heat maps are also utilized to validate the safety when working alone and the intersection situation between workers and vehicles. There is also a diversity-related case in which the feasibility of work support of low-vision and blind people is evaluated with working hours.

Fig. 4. Purposes and specific objectives extracted and summarized from Table 1.

5 Conclusion

In this paper, a wide range of actual cases are summarized to contribute to the study of how to utilize GSI to promote DX for the purpose of HPM. By dealing with multiple items related to labor productivity and QoW at the same time, the organizations will be able to maintain a high balance between them. We summarized the indicators used in each of the cases listed in Table 2 as shown in Fig. 5. It demonstrates that there are diverse but common indicators obtained directly or indirectly from geospatial data, and that they can be easily applicable by GSI. In fact, in the specific case of the Japanese restaurant introduced in section 3, the combination of geospatial data such as flow lines and POS data was able to simultaneously handle multiple indicators associated with productivity, health, rewarding, and workability for HPM. In addition, the organizations also receive the advantage of being able to disperse the initial/running costs of GSI over several purposes rather than just for a single purpose [15].

DX means digitizing 6M information, including geospatial information, and transforming products, services, business processes, and ultimately the organization. However, it takes a long time to see results after digitization, and not a few organizations find it difficult to gain understanding of GSI implementation from both the executive labor sides. The only way to achieve this drastically is to spread the concept of DX throughout society, but making it easier to introduce, operate, and maintain the GSI infrastructure and improving interoperability in groups such as supply chains using 6M data will also contribute to promoting the application of GSI at the

practical level. In addition, geospatial artificial intelligence (GeoAI) technologies [16] based on machine learning are likely to attract more and more attention from service and manufacturing industries from now on. We will continue our research and development on how GeoAI can combine the evaluation indicators summarized in Fig. 5 and utilize them for the purpose summarized in Fig. 4, or whether new metrics can be acquired by GeoAI.

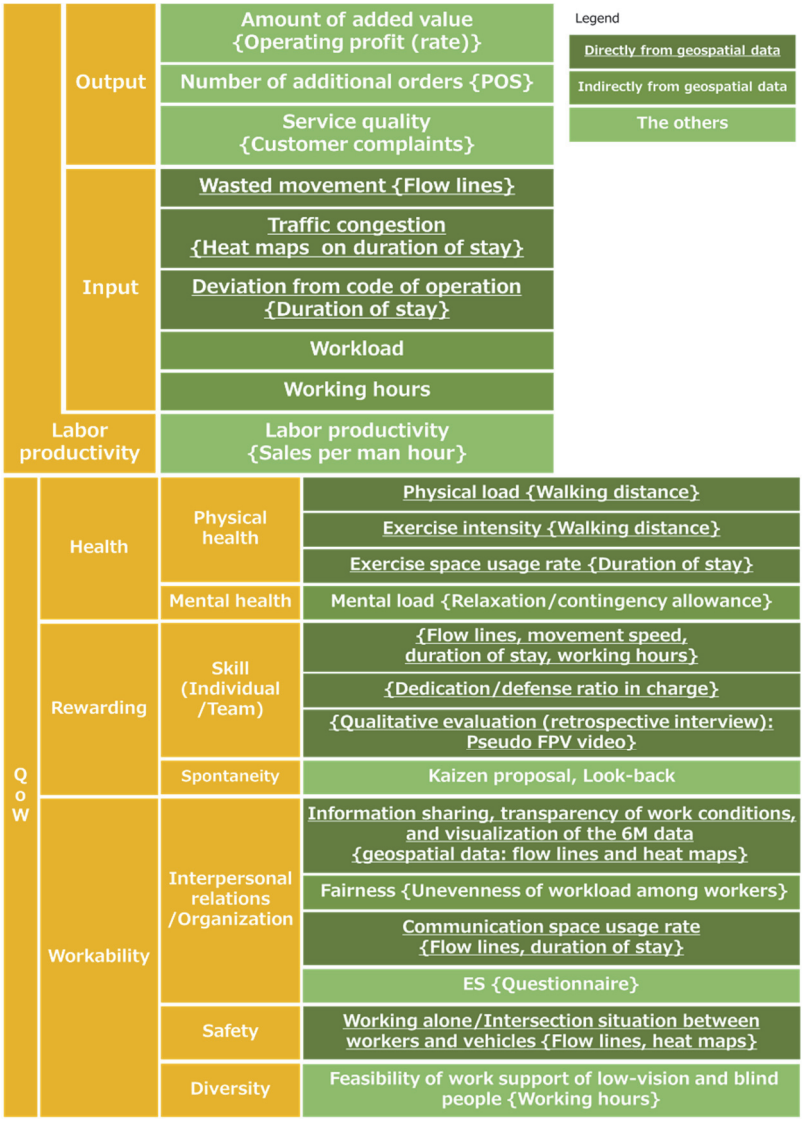

Fig. 5. Evaluation items {indicators/contents} extracted and summarized from Table 2.

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Table 1. Use cases using GSI: Purposes, objectives, methods, effects and results, positioning techs, joint research partners, and references. (PDR: Pedestrian Dead Reckoning, RFID: Radio Frequency Identification, BLE: Bluetooth Low Energy, MAP: Map matching, QC: Quality Control, OJT: On-the-Job Training).

Site [Job category]	Year	Purpose	Method	Effect and result	Positioning technologies	Joint research partners/ investigation sites	References
Nursing home [helpers, nurses]	2010	As-Is comprehension of care work flow	Flow-line measurement, descriptive statistics, interview	Process modeling, visualization of issues	PDR+ Active RFID +MAP	SUPER COURT	[6]
Japanese inn [guest room attendants]	2011	Skill analysis	Flow-line measurement, descriptive statistics, retrospective interview	As-Is comprehension of skill		Kinosaki hot springs	[7]
Japanese restaurant 1 [Customer service assistants and catering staff]	**2011**	Hospitality improvement	Flow-line measurement, descriptive statistics, QC activity	Increase in duration of stay in guest areas and additional orders		GANKO FOOD SERVICE Co,Ltd.	[8]
	2012	Physical load reduction while hospitality improvement		(In addition to the above) reduction of walking distance, skill modeling			[9]
Japanese restaurant 2 [Customer service assistants and catering staff]	**2014**	Support of new restaurant launch		visualization of issues. Kaizen effect check, rapid launch			[10]
Japanese restaurant 3 [Customer service assistants and catering staff]	**2018 -19**	Effectiveness verification of robot installation		Increase in sales per man hour and dedication in charge	PDR+BLE +MAP		[11]
Passenger plane [Flight attendant]	2015	Constructing training support environments to facilitate awareness learning	Flow-line measurement, descriptive statistics, process modeling, retrospective interview	Skill modeling in serving drink, training support		University of Tokyo, ANA Strategic Research Institute Co., Ltd.	[12]
Office [office worker]	2016	Improving office environmens (Communication/exercie space installation)	Flow-line measurement, descriptive statistics	Increase in usage rate of communication and exercie spage	RGB-D camera	Fujikura Ltd.	—
Building [Building maintenance worker]	2017	Investigating effects and impacts of work restructuring	Flow-line measurement, descriptive statistics, Questionnaire, interview	Clarification of effects and issues before and after the restructuring	PDR+BLE +MAP	KAJIMA TATEMONO SOGO KANRI CO.,LTD.	[13]
Distribution warehouse 1 [Picker]	2014	As-Is comprehension of picking work flow, Kaizen simulation	Flow-line measurement, descriptive and inferential statistics, process modeling, interview	Process modeling, To-Be simulation to compare Kaizen plans	Visible Light Communication	Frameworx, Inc., TRUSCO NAKAYAMA Corporation	[14]
Distribution warehouse 2 [low-vision/blind subject]	2018 -19	Effectiveness check of work support of low-vision and blind workers	Picking operation instructions based on positioning	Feasibility confirmed	Passive RFID	GOV Co.,Ltd., TRUSCO NAKAYAMA Corporation	—
Cable factory 1 [Manufacturing worker]	2018 -19	Workload leveling	Flow-line measurement, descriptive statistics, information sharing, OJT, retrospective interview	Workload leveling, Clarification of issues	BLE	Sumitomo Electric Industries, Ltd.	—
Cable factory 2 [Manufacturing worker]	2018 -	Simultaneous support for productivity improvement, safety management, and health management	Flow-line measurement, descriptive statistics, information sharing, POC	—	PDR+BLE +MAP		[2][15]

Table 2. Use cases using GSI: Evaluation items on labor productivity and QoW (outside {}: evaluation items, inside {}: evaluation indicators and contents used, bold: indirectly related to geospatial data, bold underlined: directly related to geospatial data).

Site [Job category]	Evaluation item {indicators and contents}										
	Lobor productivity		QoW								
			Health		Rewarding			Workability			
	Output	Input	Physical	Mental	Skill: Hospitality	Skill	Spontaneity	Interpersonal relations/ Organization	Safety	Diversity
Nursing home [helpers, nurses]		**Wasted movement {Flow lines}**				Individual and team skills **{Flow lines, duration of stay}**				
Japanese inn [guest room attendants]					Subjective skill description **{Pseudo FPV video}**					
Japanese restaurant 1 [Customer service assistants and catering staff]	Number of additional orders {POS}	**Wasted movement {Flow lines}**	Physical load **{Walking distance}**		Customer service time **{Heat maps, Duration of stay in guest areas}**	Individual and team skills {POS, **Dedication/defense rate in charge**}	Kaizen proposal	Information sharing, transparency of work conditions **{Geospatial data}**		
Japanese restaurant 2 [Customer service assistants and catering staff]	Labor productivity {Sales per man hour}				Dedication **{Heat maps}**					
Japanese restaurant 3 [Customer service assistants and catering staff]					Individual and team skills **{Dedication rate in charge}**					
Passenger plane [Flight attendant]					Interpersonal defference in serving drink **{Flow lines}**		Look-back			
Office [office worker]	Amount of added value {Operating profit (rate)}		**Exercise space usage rate {Duration of stay}**					descriptive statistics of communication **{Flow lines, duration of stay}**		
Building [Building maintenance worker]	Service quality {Customer complaints}	Workload in office, **Wasted movement {Flow lines}**	Physical load **{Walking distance}**	Mental load **{Relaxation/contingency allowance}**				ES {Questionnaire}		
Distribution warehouse 1 [Picker]		**Traffic congestion {Heat maps}, Workload per man hour, working hours per team**				Objective skill **{movement speed, working hours}**		Fairness **{Unevenness of workload among workers}**		
Distribution warehouse 2 [low-vision/blind subject]		Comparison between sighted and low-vision/blind subjects {working hours}								Feasibility of work support of low-vision and blind people {Working hours}
Cable factory 1 [Manufacturing worker]		Deviation from code of operation **{Duration of stay}**				Interpersonal difference **{Duration of stay}**		Information sharing, transparency of work conditions **{Geospatial data}**		
Cable factory 2 [Manufacturing worker]		**Wasted movement {Flow lines}**	Physical load/Exercise intensity **{Walking distance}**					Information sharing, transparency of work conditions, 6M visualization **{Geospatial data}**	Working alone/Intersection situation between workers and vehicles **{Flow lines, heat maps}**	