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Comparative Study on Pedestrian Density Analysis and Spatial Efficiency Improvement for the Homogeneous Use of Public Space in Health Examination Centers

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Abstract: ***Due to the oversupply of medical services, competition in the medical field is fiercer than ever. Medical institutions now face a situation where they must actively cope with internal and external changes in the market. The first priority in this situation should be the patients' satisfaction of service, as they are the customers. As one of the major medical institutions, health examination centers are relatively more influenced by spatial services such as congestion and time delays. The reasons are due to standardized costs as well as the fact that they are less affected by medical technology or medical equipment. However, health examination centers need to establish optimal alternatives in limited circumstances due to limited space and manpower. Furthermore, they need to shut down the system to improve the space. Discrete event simulation is receiving the spotlight as a solution to solve these issues. It is also actively used as an analysis tool for research on complex situations such as medical facilities. Therefore, the purpose of this study is to identify a way to reduce waiting time at the health examination center from a spatial perspective by using discrete event simulation. This study applied discrete event simulation to the floor plan of a health examination center at the time of opening and the current operating floor plan to compare and analyze the spatial efficiency according to the standard examination process. A new floor plan that improves the problems derived from the analysis process was then established to quantitatively and qualitatively verify the degree of improvement. As indicators for quantitative evaluation, we proposed and measured the examinee processing time(D), the average examination time per person(P), and the number of people waiting per examination item(q) for 100 people. We also performed an intuitive evaluation based on heat map analysis and the distribution of examination time. For the reliability of the analytical data, we repeated the simulation 10 times and applied the mean value. The current operating floor plan reduced the examination processing time for 100 people by 15.29% and the average examination time per person by 11.64% compared to the plan at the time of opening. We also found that the highly congested waiting area of the turnaround section in the south and east corridors moved to the east corridor and that the homogeneity of examination time per person improved. This improvement is considered as a result of experience from operating for a considerable period of time after opening. As a result of proposing and analyzing the improvement plan that partially adjusted the number of services and the layout of examination rooms to distribute the concentrated queues in the narrow corridor space, the examination time per person could be further reduced by 7.02% compared to the current operating floor plan. Moreover, the public space could be used more homogeneously due to the wider use of the waiting space(corridor). Discrete event simulation shows that preliminary verification, configuring alternatives, and preparing reliable improvement plans is possible even without stopping system operations. More optimized results can be obtained by applying this theory to the initial design stage in addition to maximizing cost savings. However, discrete event simulation is an operational (low-abstract) model that is applicable to a relatively small independent space. If we integrate modular DES with Strategic Models such as System Dynamic (SD), we may be able to perform macro-level analyses. Therefore, follow-up studies will be required in the future.***

KEYWORDS : *Discrete event simulation, Health examination center, Complex system, Pedestrian model, Pedestrian density, Examinee queue*

I. INTRODUCTION

As one of the medical services provided by hospitals, the examination center has a consistent structure that performs designated examinations according to a certain procedure. This feature is in contrast to other hospital functions, including the outpatient department. It is also a facility that is largely influenced by environmental service quality compared to other factors due to standardized examination fees and less impact of medical technology[1]. Accordingly, the quality and customer satisfaction of the examination center is considered to be highly influenced by spatial environment convenience.

Moreover, the concept of modern health care is expanding from treatment to prevention, and from patients to the general public (potential patients). As a result, the examination center, which was merely an affiliated function of hospitals, has now emerged as an independent function[2].

The demand for medical services has increased significantly along with the interest in health due to better economic conditions. However, excessive supply rates that have exceeded the demand led to a quantitative saturation of the health care market. As a result, hospitals are now facing a new aspect in terms of customer satisfaction, or quality competition.

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Hospitals also face the chronic problem of increasing operating costs compared to the stagnant costs of the actual medical treatment charges.

In reality, however, it is difficult to improve the quality due to the limited expenditures compared to the production and limited space problems.

It is also a challenge to establish a confident improvement plan because the healthcare system is highly complicated and because the system cannot be shut down for long periods of time for improvement.

Under these circumstances, researchers and healthcare professionals considered discrete event simulation (hereinafter DES) as a new approach to improve the efficiency of health care operations. DES is now widely used by hospital managers or decision makers as a tool to support efforts to achieve quality improvement goals[3].

Therefore, the purpose of this study is to improve spatial quality in terms of the relationship between the homogeneity of the public space in examination centers and the examination service using DES.

DES is a complex system analysis method, which results in a certain emergence phenomenon. However, as variables are generated in the attribute of the applied agent even in the same model, there is a difference in the result values for each simulation. Therefore, this study calculated the results by aggregating (mean and maximum value) 10 repeated simulations as it is more reliable to obtain generalized values through iterative simulations.

II. SIMULATION CONFIGURATIONS

A. Medical Facility & DES

If hospitals do not actively cope with internal and external environmental changes due to fierce competition in the healthcare market, they may face significant risks due to deteriorating management performance.

In order to solve these problems, the first priority should be the patients' satisfaction, as they are the customers. In addition to treating diseases, which is the intrinsic purpose of hospitals, the medical process or the process in the hospital until receiving a treatment, is also an important factor in customer satisfaction[4].

Unlike general treatment, hospitals are also heavily influenced by the spatial environment rather than by medical technologies, where patients can receive examinations in a comfortable environment. Particularly in the medical process, reducing medical treatment and therapy time in hospitals is perceived as an important factor[5].

Unlike ordinary customers who wait in positive situations such as going to the theater or eating delicious meals, the waiting time has a greater impact on patient satisfaction because they are waiting in negative situations such as receiving treatment[6].

In reality, however, hospitals experience difficulties in increasing facilities or hiring doctors or nurses due to various resource limitations, even though it is important to reduce waiting times. Even if hospitals have the will to increase the number of facilities or staff, they need to know in advance how to estimate the optimal effect at a low cost[7]. However, this analysis and forecasting work is complex due to the nature of medical facilities which have very complicated relationships between functions (areas).

DES is drawing attention as an analytical methodology to analyze the inherent complexity of healthcare systems[8]. This can be confirmed by analyzing the citations of papers published in recent decades which have shown a sharp increase in the number of papers related to healthcare systems using DES since 2004[9].

Although the number of studies applying DES to medical facilities has increased, most of the studies apply DES to the administrative work process[10] or independent functions such as the emergency room[11,12,13,14,15].

DES originates from the hierarchical formalism of Discrete Event System Specification (DEVS) invented by Bernard P. Zeigler, which describes the dynamic change of a system in terms of state transition with the occurrence of an event.

DES is a computer simulation analysis technique of DEVS. DES models the system as a network based on the activity of queues and agents, and the state transition of the system occurs at individual points in time. The object (agent) in the system acts as a distinct "individual." and each individual has the nature to determine what will happen to oneself.

Agents in the simulated space respond to environmental changes, and are autonomous and independent but have the flexibility to act consistently with the will to achieve given goals. It also interacts with other agents and has the property to continually feedback (recover) from failures[16].

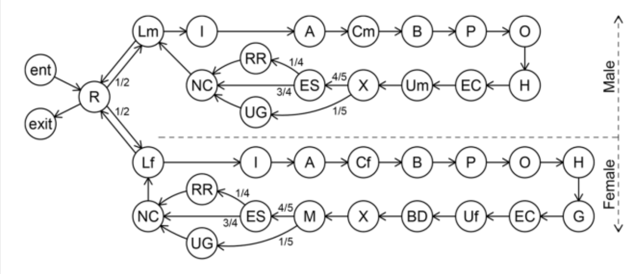
B. Setting the Required rooms & Examination Process (Workflow)

Effective patient flow can be described by the three areas of high patient processing capacity, short patient waiting time, and examination room service time, which requires proper staff allocation and low physician idle time.

Previous studies define patient scheduling and admissions, patient routing and flow schemes, and scheduling and availability of resources as the three areas that affect patients in medical facilities[17].

This study intends to find improvements by adjusting the number of services and the layout of examination rooms while the variables of patient scheduling and admissions and patient routing and flow schemes are in a fixed state.

In terms of configuring the examination procedure and examination time, which are fixed variables, we developed and applied the workflow shown in [Figure 1] by considering the paper by Kim[1], which integrates the research of Song[18], Jung[19], and Han[20].



Code	Description	Services	Min	Max	Code	Description	Services	Min	Max
R	Reception	3	2.0	3.0	**G**	Gynecology	1	3.0	7.0
Lm	Locker room(male)	20	5.0	10.0	**EC**	Electrocardiogram	1	2.4	4.0
Lf	Locker room(female)	20	8.0	14	**U**	Ultrasound	3	8.0	12.0
I	Medical examination by Interview	3	2.0	3.0	**BD**	Bone Density	1	3.0	5.0
A	Anthropometric Measurement	1	2.0	3.0	**X**	X-ray	1	2.0	3.0
Cm	Collection of urine(male)	1	1.0	1.5	**M**	Mammography	1	4.0	6.0
Cf	Collection of urine(female)	1	2.0	3.0	**ES**	Endoscope	2	5.0	10.0
B	Blood Gathering	1	1.0	1.5	**RR**	Recovery Room	1	25.0	35.0
P	Pulmonary Function Test	1	2.5	3.5	**UG**	Upper Gastrointestinography	1	8.0	12.0
O	Ophthalmology	1	3.0	5.0	**NC**	Nutrition Consultation	1	2.0	3.0
H	Hearing Test	1	2.0	3.0					

Figure 1. Examination procedure applied to the analysis

C. Evaluation Index & Index Measurement Algorithm

This study added an index calculation routine in the process model of the simulation to derive 3 quantitative indexes of the time to process 100 examinees (agents) (D), the average examination time per person (P), and the number of people waiting per examination item (q). In addition, we performed intuitive analysis such as density distribution heat map and examination time histogram per person to identify the problems and suggest directions for improvement. The purpose of each index is as follows.

Examinee processing time (D): The time required to complete examinations for 100 people, which can be used to understand the overall allocation of services and the flow efficiency.

1) Number of people waiting per examination item (q): To identify whether the number of services (manpower) has been reasonably allocated by examining the queue by examination room.
2) Average examination time per person (P): To identify the predictability of time required to examine the examinee along with the distribution of examination time.
3) Density distribution heat map: Used to identify the homogeneous use and bottlenecks of the public space.
4) Distribution of examination time by section (histogram): Used to identify the uniformity (equality) of the examinee's average examination time.

III. ANALYTICAL SIMULATION

A. Plan-O Analysis

As a result of analyzing the simulation of the floor plan at the time of opening (Plan-O), it took 30,932.1 seconds to complete examinations for 100 people and the average time per person (P) was 20,434.25 seconds. This is a remarkably long period of time for examinations at an actual examination center and was not considered in this study as it was for comparison between the alternatives.

The first reason why the examinations took a considerably long time was due to the number of people q (A) waiting for anthropometric measurement (A), which increased up to 43 people in the span of 10,000 seconds, as shown in the left side of [Figure 2]. Later, the number of people waiting for pulmonary function test q (P) also increased to 14 within 16,600 to 17,500 seconds. However, this did not seem to be the cause of a critical time delay. Rather, the pulmonary function test (P) location was considered. As the test is located at the turnaround section (corner) of the corridor, the congestion of public space resulting from those waiting leads to an indirect time delay due to the nature of the location. This arrangement may further contribute to complex problems such as damage to the walking environment and hindering the recognition of space.

Instead, the number of people q (O) waiting for the following ophthalmology (O) examination increased to 27 in the span of 20,300 seconds, which was a greater cause of time delay.

In terms of the distribution and density of pedestrians [right side of Figure 2], the density increases significantly in the corridor (waiting space) in front of the 3 examination rooms where service delays occur. In particular, confusion and disorientation may occur from the pedestrian's perspective because a high-density area occurs at the center of the turnaround section (corner) of the corridor, where it is difficult to recognize the space.

In conclusion, the actual layout of Plan-O did not use the public space in a homogeneous and rational manner. Furthermore, the spatial recognition of the examinee and the convenience of waiting people were significantly reduced due to the congestion area at the corner of the narrow corridor.

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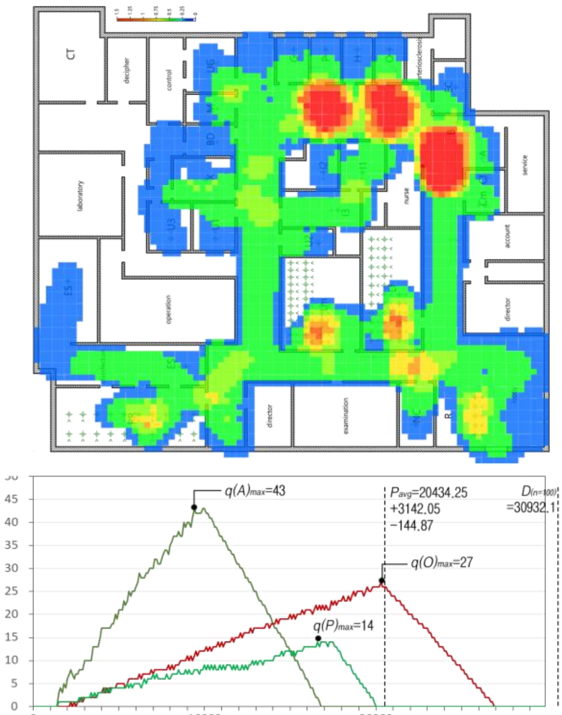

Figure 2. The queues and density of examinees in the public space of Plan-OPlan-C Density Analysis

Plan-C is the current floor plan in operation, which rearranged the space based on operational experience without any separate simulation analysis.

As a result of analyzing Plan-C by applying 100 people as in the simulation of Plan-O, the examinee processing time (D) was 26,201.4 seconds and the average examination time per person (P) was 18,054.86 seconds. Compared to Plan-O, the examinee processing time (D) was reduced by 4,730.7 seconds (15.29%) and the average examination time per person (P) was reduced by 2,379.39 seconds (11.64%).

This is an example of improving problems based on operational experience. The corresponding results from experience and simulation analysis suggest that if the plan was determined by using DES at the time of opening, reduced costs and increased reliability may have been feasible.

In terms of the changes in waiting people of Plan-C [left side of Figure 3], the results are as follows. There are no people waiting for anthropometric measurement (A) which had the largest queue in Plan-O. The ophthalmology (O) has a maximum of 24 waiting people in the span of 11,100 seconds. The hearing test (H) has 20 people waiting in the span of 14,250 seconds. Finally, the electrocardiogram (EC) has 24 people waiting in the span of 17,600 seconds, showing a lower maximum (peak) congestion. This is the result of the queue being concentrated in one particular examination (anthropometric measurement) in Plan-O and being evenly distributed into 3 services (examination rooms).

As shown in the density heat map of the [right side of Figure 3], the high-density area that occurred in the turnaround section has been transferred to the east corridor. Although the load of the queue has been distributed to 3 locations, bottlenecks still remain the flow of examinees, as the rooms that generate queues are adjacent to each other and are still located close to the turnaround section.

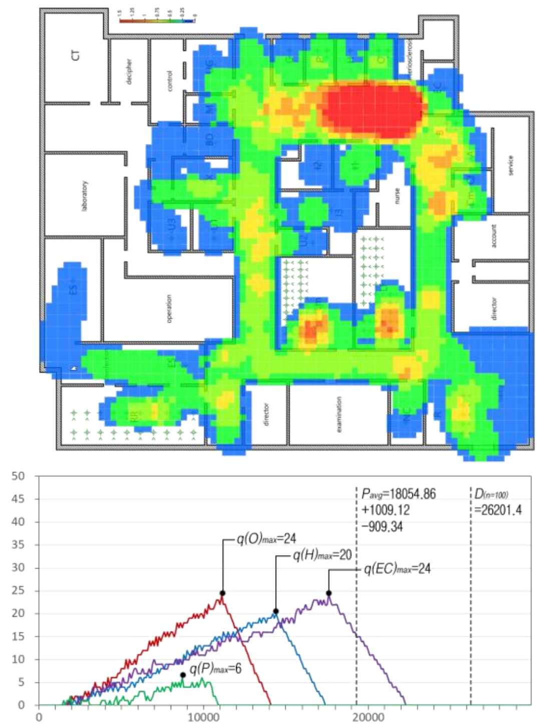

Figure 3. The queues and density of examinees in the public space of Plan-C

B. Spatial Rearrangement & Service Adjustment

If Plan-C was effective compared to Plan-O, we can assume that a more optimized alternative to the current Plan-C could have been obtained by allocating the rooms through an initial simulation. Therefore, we developed Plan-I by rearranging some of the examinations rooms in an interchangeable manner to comply with the examination procedure.

1) Add one service to each of the anthropometric measurement(A), pulmonary function(P), and ophthalmology(O), which often generated queues in Plan-O and Plan-C.
2) Reduce the medical examination by interview(I), which is currently administered in 3 locations, to 1 location and perform the examination in the waiting space.
3) Allocate gynecology(G), electrocardiogram(EC), and ultrasound(U) test areas to the 3 locations previously used as medical examination by interview.
4) Separate the blood collection(B) station currently situated in the same location as the anthropometric measurement(A) test and move to the electrocardiogram (EC) space.
5) Allocate electrocardiogram(EC), pulmonary function (P), and ophthalmology(O) to the empty spaces after moving.
6) Arrange the hearing test(H)→ pulmonary function(P)→ ophthalmology(O) according to the examination flow.

In addition, examination

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rooms that require large-scale construction equipment such as X-ray(X) or Endoscope(ES) were excluded from the adjustment in consideration of excessive cost.

C. Overall Verification & Analysis of Plan-I

Although the examinee processing time (D) was 26,757 seconds, which showed no significant difference within the error range with Plan-O, the average examination time per person (P) was 16,787.33 seconds (maximum: 19,344.96, minimum: 16,307.77), which is a 7.02% reduction compared to Plan-C.

Therefore, if optimized alternatives had been identified through simulations in the design phase before opening, the average examination time per person could have been reduced by up to 17.85%.

While the change in queues by examination item of Plan-I [left side of Figure 4] does not show a significant difference compared to Plan-C, the density distribution on the right side shows that the distribution of people waiting spread over a wider area and some moved to the south corridor. That is, we can now use the public space (corridor, waiting area) more homogeneously while reducing the density of the turnaround section where spatial recognition is low.

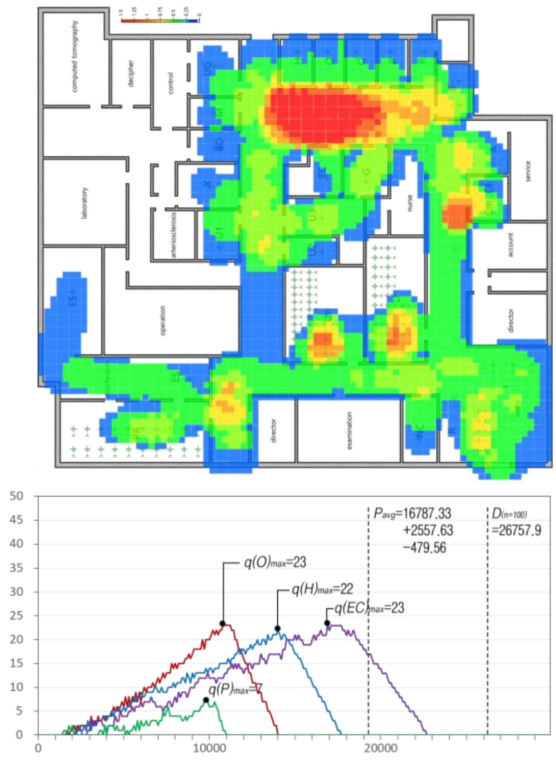

Figure 4. The queues and density of examinees in the public space of Plan-I

IV. RE-VERIFICATION THROUGH GENERAL ANALYSIS

A. Distribution of Time Required for Examination

[Figure 5] shows the distribution (histogram) of the average examination time per person (P) divided into 50 intervals and expressed as a percentage (%) by interval.

Plan-O is distributed over a wide area, indicating large fluctuations in the examination time (P) for each examinee. In particular, there are significant delays in a considerable number of cases. This shows that the examination time required for each examinee is inconsistent, which makes it difficult for the examinee to predict the time required for the examination.

In contrast, Plan-C is distributed within a certain interval compared to Plan-O. Thus, the difference in examination time by each examinee is reduced, and the cases with significant delays are also reduced. However, the number of distributed examinees appears to be somewhat unstable.

Plan-I did not show much difference from Plan-C. However, the distribution of examinees was somewhat stabilized compared to Plan-C, in which the time required for each examinee was unstable. The result, however, seems insufficient to recognize a tangible effect.

The distribution characteristics of the time required from each examinee showed similar results to the analysis on the examinee processing time(D) and average examination time per person(P), which re-verifies the respective improvement effects of Plan-C and Plan-I.

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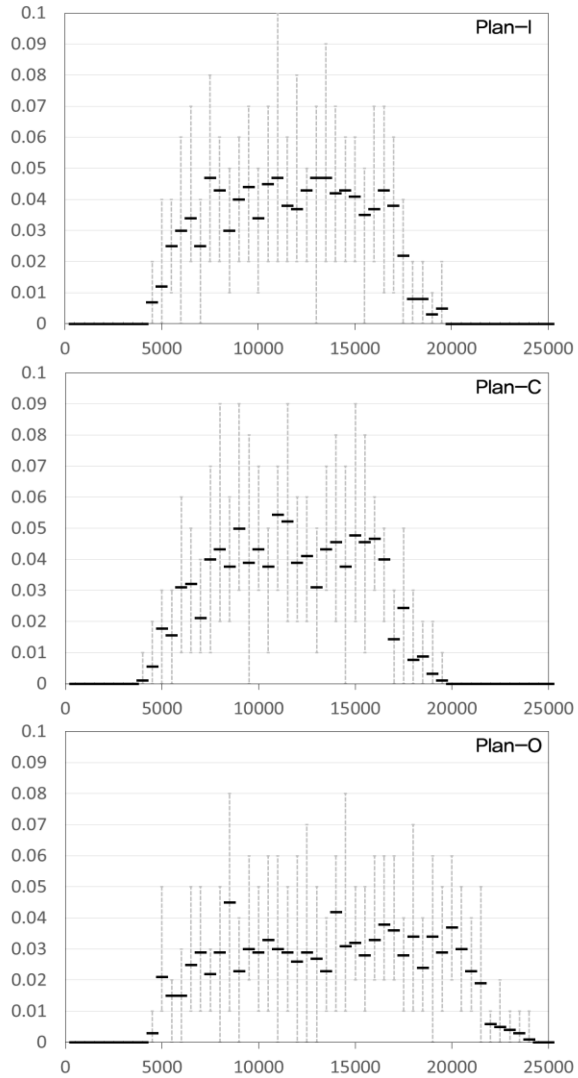

Figure 5. Histogram of the distribution of examination time per person (P)

B. Change in Density by Sector

As shown in the left side of [Figure 6], we measured the density (number of examinees per unit area) over time by installing 6 measurement sectors (2 in the south corridor and 4 in the east corridor). The 6 sectors were installed in the corridors where the pedestrian density is concentrated, which is shown in the time series graph by each plan (right side).

The simulation results show that examinees were concentrated in Sector-5 of Plan-O and the density of examinees per unit area increased to a maximum of 2.038. Sector-4 showed the highest average density (0.5307), and the overall average of the 6 sectors was 0.301. Sector-4 and Sector-5, which show high densities, are corridors immediately adjacent to the turnaround section of the corridors, and the increase in density assumed from the heat map turned out to be very high as a result of quantitative measurement.

On the other hand, the density of Sector-4 in Plan-C only increased to 1.630, which is lower than that of Plan-O, and the average density was also highest in Sector-4 (0.509). From this observation, it can be interpreted that long-term congestions are maintained in Sector-4, which is a corner section, and a higher average value than the maximum value indicates that the density is distributed over time.

In terms of Plan-I, the maximum density only increased to 1.510 in Sector-2, which is even lower than that of Plan-C. Moreover, the congestion was further reduced as the high-density area (Sector-2) moved away from the turnaround section of the corridor.

The average density was highest in Sector-2 (0.572), and the overall average also slightly increased to 0.233, showing that density concentration over time had also been greatly mitigated.

In addition, while the high-density areas of Plan-C are concentrated in the east corridor (Sectors 3 and 4), they are evenly distributed into 4 sectors in Plan-I.

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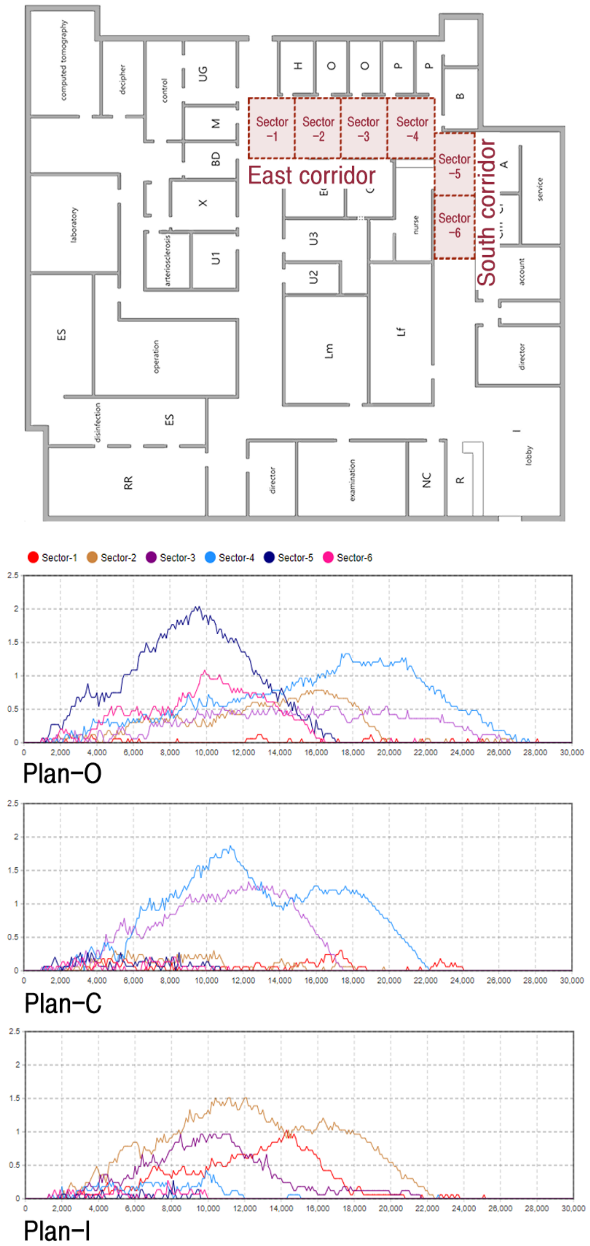

Figure 6. Trend of density change by sector

V. CONCLUSION

As a result of performing DES analysis on the floor plan of a currently operating examination center, we found that the examinee processing time (D) and average examination time per person (P) significantly improved from the time of opening.

The fact that the current plan, which improved problems based on operational experience, was consistent with the DES analysis shows that these results were predictable using DES in advance. This also demonstrates the effectiveness of DES, which indicates the feasibility of significantly reducing costs through optimization by DES before opening.

Therefore, as a result of allocating space (examination rooms) using DES, assuming that the hospital has not yet opened, the average examination time per person (P) was reduced by 7.02% compared to the current floor plan and by 17.8% compared to the time of opening. Moreover, the congestion of space was reduced by spreading the density that was concentrated in the turnaround section where spatial recognition is low. In addition, predicting the time required for each examination was improved as the distribution of examination time was stabilized within a certain interval. Therefore, we can conclude that optimizing spatial layout by DES is greater than the effects obtained by experience.

As DES is capable of empirical analysis compared to other spatial structure theories, it can be used as a valuable tool if sufficient data is obtained from the agents in a given space. In addition, simulations can be verified without shutting down the existing system. Therefore, we can identify effective improvement measures for allocating space and resources even when simulations are applied to facilities in operation.

VI. ACKNOWLEDGMENT

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VII. REFERENCES

1. S. T. Kim, “Research on Space Systemization and Reduction of Examination Time of Medical Checkup Centers Applying the Agent based Model”, *International Journal of Engineering & Technology*, Vol 8, No.1.4, pp.356-368. Available : https://www.sciencepubco.com/ index.php/ijet/article/view/ 25248/12872
2. R. F. Dyer, and E. H. Forman. “An Analytic Approach to Marketing Decisions”. 1991.
3. Jacobson, Sheldon H., Shane N. Hall, and James R. Swisher. "Discrete-event simulation of health care systems." *Patient flow: Reducing delay in healthcare delivery*. Springer, Boston, MA, 2006. 211-252.
4. K. E. Oh, et al. "Developing Innovation Index of Hospital Service Using 6 Sigma and SERVQUAL", *Journal of the Korean Society for Quality Management*, Vol.41, No.4, 2013, pp.555-566. Available : http://www. jksqm.org/upload/pdf/PJGOB9_2013_v41n4_555.pdf
5. D. Kathryn H, and J. Miles, "Patient satisfaction with ambulatory healthcare services: waiting time and filling time", *Journal of Healthcare Management.* Vol.42, No.2, p.165, 1997
6. C. K. Park and E. J. Kwag, "A case study about managing waiting time for raising customer's satisfaction in the medical service", *Korea Journal of Hospital Management*, Vol.14, No.3, 2009, pp.132-153.
7. H. J. Yeo, W. S. Bak, M. C. Yoo, S. C. Park and S. C. Lee , “Evaluation of patients' queue environment on medical service using queueing theory”, *Journal of the Korean Society for Quality Management*, Vol.42, No.1, 2014, pp.71-79. DOI:10.7469/JKSQM.2014.42.1.071
8. Barnes, C. Drury and K. R. Laughery. "Advanced uses for micro saint simulation software", *1998 Winter Simulation Conference. Proceedings (Cat. No. 98CH36274)*. Vol.1, IEEE, 1998.
9. M. M. Günal and P. Michael "Discrete event simulation for performance modelling in health care : a review of the literature", *Journal of Simulation*, Vol.4, No.1, 2010, pp.42-51.
10. Reynolds, Matthew, et al. "Using discrete event simulation to design a more efficient hospital pharmacy for outpatients." *Health care management science* 14.3 (2011): 223-236.
11. Duguay, Christine, and Fatah Chetouane. "Modeling and improving emergency department systems using discrete event simulation." *Simulation* 83.4 (2007): 311-320.
12. Hoot, Nathan R., et al. "Forecasting emergency department crowding: a discrete event simulation." *Annals of emergency medicine* 52.2 (2008): 116-125.
13. K. Alexander and M. Ali, "Modeling emergency departments using discrete event simulation techniques." *Proceedings of the Winter Simulation Conference, 2005.*. IEEE, 2005. DOI:10.1109/ WSC.2005.1574570
14. G. R. Hung, et al., "Computer modeling of patient flow in a pediatric emergency department using discrete event simulation." *Pediatric emergency care*, Vol.23, No.1, 2007, pp.5-10. DOI:10.1097/PEC.0b 013e31802c611e

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15. M. Raunak, L. Osterweil, A. Wise, L. Clarke, and P. Henneman, "Simulating patient flow through an emergency department using process-driven discrete event simulation." *Proceedings of the 2009 ICSE Workshop on Software Engineering in Health Care*. IEEE Computer Society, 2009. DOI:10. 1109/SEHC.2009.5069608
16. N. Ronald, S. Leon and M. Kirley, "An agent-based approach to modelling pedestrian behaviour", *International Journal of Simulation*, 8.1 (2007): 25-38.
17. J. B. Jun, H. J. Sheldon, and J. R. Swisher. "Application of discrete-event simulation in health care clinics: A survey", *Journal of the operational research society*, Vol.50, No.2, 1999, pp.109-123.
18. S. E. Song and S. T. Kim, "A Study on Traffic Line Efficiency of Health Examination Centers Based on Space Syntax-Focused on the Spatial Cognition of the Testee Taking the National Examination Program", *Journal of The Korea Institute of Healthcare Architecture*, Vol.18, No.4, 2012, pp.53-65. Available : http://koreascience.or.kr/article/JAKO201217761680770.page
19. J. H. Jung. "Study on the space plan of a health examination center based on environmental psychological behavior", Master's Thesis. Hanyang University, Republic of Korea, 2011. Available : http://www.riss.kr/search/detail/DetailView.do?p_mat_type=be54d9b8bc7cdb09&control_no=30ce643d45ae7016ffe0bdc3ef48d419
20. S. W. Han, "A Study on the Spatial Composition & Using Circulation of Health Promotion Center in General Hospital", Master's Thesis. Hanyang University, Republic of Korean, 2008, Available : http://www.riss.kr/search/detail/DetailView.do?p_mat_type=be54d9b8bc7cdb09&control_no=c46f2150718c05abffe0bdc3ef48d419

VIII. AUTHORS PROFILE

First Author Dr. Kim got his Ph.D in Architecture from Hanyang University. At present, he is a Professol in the Department of Interior Architecture at Inje University, Gimhae(South Korea)