A Development of Optimization Model for Construction Site Layout Planning Using Genetic Algorithm

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Abstract

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1. Introduction

2. Problem statement

3. Literature review

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4. Methodology

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4.1 Input Module:

A two-dimensional grid:

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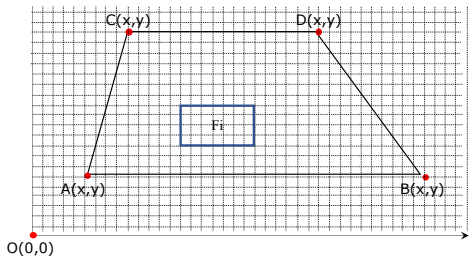

Fig. 1 Representation of construction site and facility shape

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4.2 Constraint module

4.2.1 Site boundary

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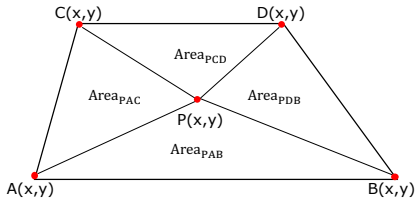

Fig. 2 Criteria for point P inside trapezoid

$$Area_{PAC} + Area_{PCD} + Area_{PDB} + Area_{PAB} = Area_{ABDC} \quad (1)$$

4.2.2 Non-overlapping constraint

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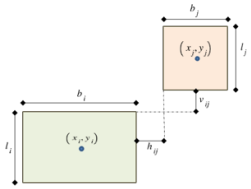

Fig. 3 Non-overlapping objects

$0.5(b_i + b_j) + h_{ij} - |x_i - x_j| \le 0$ ( ) ( )

$0.5(l_i + l_j) + v_{ij} - |y_i - y_j| \le 0$ ( ) ( )

$\mathrm{Min}\left(0.5(b_i + b_j) + h_{ij} - |x_i - x_j|, 0.5(l_i + l_j) + v_{ij} - |y_i - y_j|\right) \le 0$ ( )

(x_i, y_i) (x_j, y_j)

, b_i , l_i

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, h_{ij}, v_{ij}

4.2.3 Tower crane reachability

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$$\sqrt{(x_i - TX_t)^2 + (y_i - TY_t)^2} - R \le 0 \quad ( )$$

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$$\sqrt{(FCX_i - TX_t)^2 + (FCY_i - TY_t)^2} - R \le 0 \quad ( )$$

(FCX_i, FCY_i)

( ) ( ), (TX_t, TY_t)

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4.2.4 Safety for flammable and accommodating facilities

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$$\sqrt{(FCX_i - TX_t)^2 + (FCY_i - TY_t)^2} - R \ge 0 \quad ( )$$

4.2.5 Collision avoidance

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$$\sqrt{(TX_{ti} - TX_{tj})^2 + (TY_{ti} - TY_{tj})^2} \ge Max(R_i, R_j) \quad ( )$$

(TX_{ti}, TY_{ti}) (TX_{tj}, TY_{tj})

( ) ( ) R_i, R_j

( ) ( )

4.3 Objective function

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$$Fval = Min\left(\sum_{i=1}^{n-1}\sum_{j=i+1}^{n} d_{ij} C_{ij}\right) \quad ( )$$

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$$d_{ij} = \sqrt{(X_j - X_i)^2 + (Y_j - Y_i)^2} \quad ( )$$

n

, , $(X_i, Y_i), (X_j, Y_j)$

(C_{MEF}), (C_{SE}), (C_{mpi})

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$$C = C_{MEF} + C_{SE} + C_{MPI} \quad ( )$$

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Table 1

Table 1 Proximity weights used for closeness relationships

Desired relationship	Proximity weight
Absolutely necessary (A)	$6^5 = 7776$
Especially important (E)	$6^4 = 1296$
Important (I)	$6^3 = 216$
Ordinary closeness (O)	$6^2 = 36$
Unimportant (U)	$6^1 = 6$
Undesirable (X)	$6^0 = 1$

4.4 Genetic Algorithm for facility location optimization

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Table 2

Table 2 Encoded chromosome of gene variables

x1	y1	x2	y2	x3	y3	...	...	xn	yn

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p(mut)

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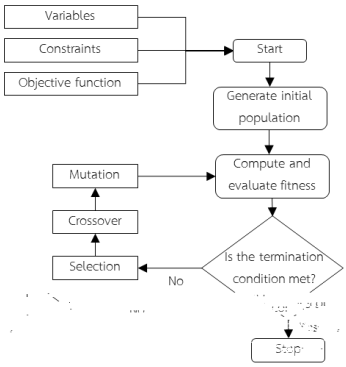

Fig. 4 Optimization process of GA

5. Prototype testing

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Table 3

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, C_{MEF}, C_{SE},

, C_{mpi}

ID	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	B1	B2
F1	0	1728	78	18	3888	78	13	13	3	3	228	18	13	13	8028	23328	15768	8	8
F2		0	78	48	1548	468	78	43	3	3	13	13	8	8	23328	23328	15768	13	13
F3			0	0	1728	438	288	13	8	8	43	43	8	8	468	108	108	48	48
F4				0	78	43	3888	2598	1548	1548	1548	1368	1308	1308	43	1368	1368	258	258
F5					0	2628	1338	228	8	8	18	18	3	3	15768	23328	10368	43	43
F6						0	1308	48	3	3	18	18	8	8	18	648	648	18	18
F7							0	1338	16848	16848	16848	9108	3	3	18	48	48	23328	2808
F8								0	23328	23328	1368	1368	3	3	18	48	48	15768	10368
F9									0	0	18	18	7813	7813	0	3	3	15588	23328
F10										0	18	18	7813	7813	0	3	3	108	23328
F11											0	0	0	0	0	0	0	0	0
F12												0	0	0	0	0	0	0	0
F13													0	0	0	0	0	0	0
F14														0	0	0	0	0	0
F15															0	0	0	0	0
F16																0	0	0	0
F17																	0	0	0
B1																		0	0
B2																			0

Fig. 5 Total closeness relationship matrix

Table 3 List of facilities used in this study

ID	X	Y	Facility	Type	Dim(b, l)
F1	x1	y1	Car parking	TF	6,10
F2	x2	y2	Guardhouse	TF	3,3
F3	x3	y3	Labour resting area	TF	4,4
F4	x4	y4	Machine room	TF	4,4
F5	x5	y5	Site office	TF	8,10
F6	x6	y6	Washroom	TF	4,3
F7	x7	y7	Material storage	TF	15,8
F8	x8	y8	Rebar fabrication and bending yard	TF	20,12
F9	x9	y9	Tower crane#1 (R=35m)	TF	2,2
F10	x10	y10	Tower crane#2 (R=32m)	TF	2, 2
F11	37	13	Material hoist#1	Fixed	2,2
F12	90	29	Material hoist#2	Fixed	2,2
F13	52	33	Refuse chute#1	Fixed	4,2
F14	110	29	Refuse chute#2	Fixed	4,2
F15	33	0	Site entrance	Fixed	6,2
F16	33	20	Haul road#1	Fixed	6,40
F17	78	37	Haul road#2	Fixed	84,6
B#1	47	17	Building#1	Fixed	18,30
B#2	101	15	Building#2	Fixed	24,26

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Table 4 ( )

Table 4.

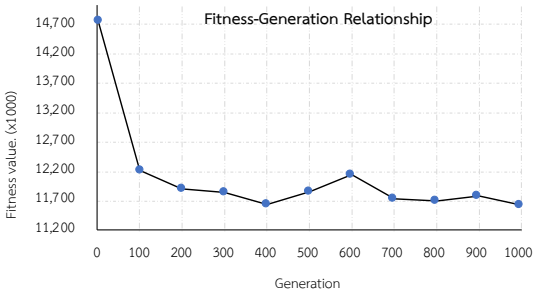
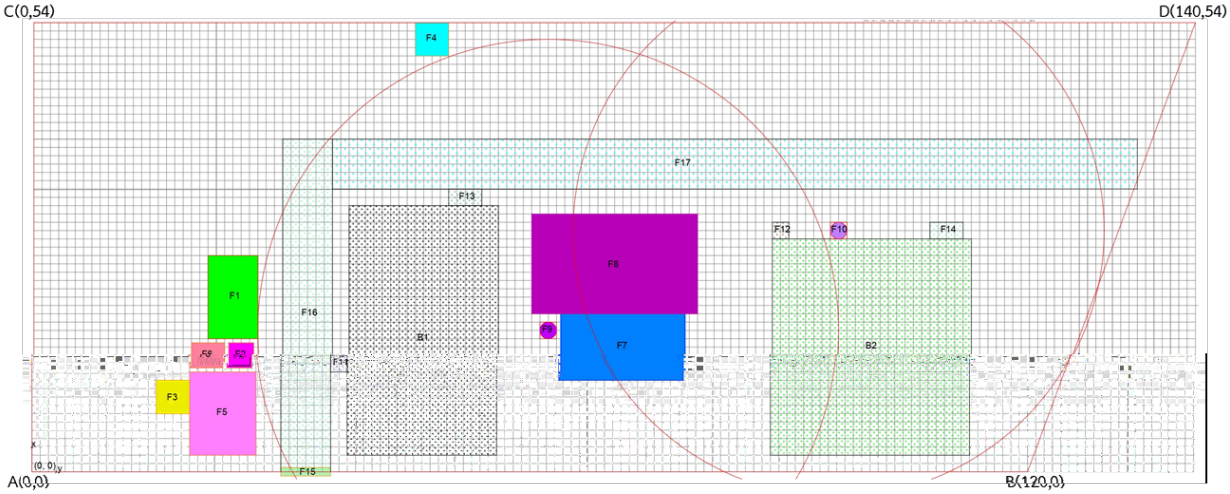


Fig. 6 Fitness-generation relationship

Table 4 Variations of fitness values

No. testing	Fitness value	Avg. improvement
Initial	14,771,781	20%
1	11,646,415	
2	12,623,190	
3	11,651,597	
4	11,473,525	
5	11,889,623	
Average	11,856,870	

x1	y1	x2	y2	x3	y3	x4	y4	x5	y5	x6	y6	x7	y7	x8	y8	x9	y9	x10	y10
24	21	25	14	17	9	48	52	23	7	21	14	71	15	70	25	62	17	97	29



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6. Conclusions

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