Optimal Positioning of Elevator Hoistways in Buildings based on a Simplified Circulation Model

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In modern multi-storey buildings, the location of elevator systems is a very crucial factor regarding the efficiency of transportation service and the comfortable and easy on-floor circulation. The present paper proposes a method which, after the partition of a typical floor of a commercial building into cells by a grid, correlates architectural and circulation data for the formulation of functions and matrices that demonstrate numerically the architecture of the floor, the design of circulation spaces and the presented need for elevator service in each cell. Then, weighted Euclidean norms and modified heuristic search algorithms are used to find the position of the elevator hoistway that fits the existing architectural plan and is closest to the point of floor's circulation paths that presents the minimum mean walking distance from the entrances of the areas that host floor's population. A case study demonstrates effectively the proposed method.

Keywords: optimization algorithm, architectural design, elevator design, inner-building circulation

1. INTRODUCTION

In a modern multi-storey building, the approppriate selection of the position of the elevator system is very important for the efficient vertical transportation of the building's occupants. The users of the system should reach it easily and, after landing to the floor of their demand, they should walk to the space they want with the fewest movements. On the other hand, the arbitrary selection of the position of the elevator system can lead to overcrowded on-floor circulation conditions, with bottlenecks and unreasonably long walking distances to/from the system. In that case. occupants' incovenience may increase significantly with very negative consequences to their activities and, finally, to the building's trading value.

Artificial and computational intelligence offers excellent tools for the evolution of designing methods for various electromechanical systems. Indeed, there are many approaches for the optimization of elevator systems in the fields of mechanical parameters configuration, control systems and cost planning. Contrary to the above fields, research reveals that there are only a few worth to-be-mentioned approaches dealing with the issue of positioning an elevator system in a multi-storey building.

In [1], Marmot and Gero consider the problems posed in designing elevator lobbies and establish an empirical model which analyzes data extracted from twenty real buildings in order to formulate equations and charts as designing tools for lobbies.

In another article Goetschalckx and Irohara [2] examine the floor layout problem in multi-storey buildings which include elevators and they introduce an optimization algorithm which examines several floor-layout formulations for finding the one that presents the minimum sum of vertical and horizontal material transportation cost. The algorithm considers the type and number of the elevators, as well as their position relatively to candidate shapes that compose the examined floor-layout formulations.

Matsuzaki and al. [3] deal with the same problem with Goetschalckx and Irohara and present an optimization algorithm that retrieves the floor layout formulation with the minimum sum of vertical and horizontal material transportation cost, not only considering the type, mumber and location of elevators, but also their capacity. Simulated Annealing and Genetic Algorithms are used in the proposed algorithm.

Closer to the problem of determination of the position of passenger elevator systems in commercial buildings is the work of P. Markos and A. Dentsoras [4]. Here, a typical floor plan of a commercial building with distinctive use of spaces is partitioned by a grid into square cells. A circulation index is proposed as a function that correlates structural/architectural data (net usable space, circulation space, structural intrusions etc.) and population's circulation data (population size and density, possibility of use of elevators during morning peak time etc.) referring to the floor under consideration. The value of this index is uniquely calculated for every cell of the partition grid and, susequently, it is used in Euclidean norms which are combined with an exhaustive search algorithm that scans all cells and eventually locates the cell that presents the minimum weighted mean distance from all cells of all usable spaces. This cell represents the optimum position of the elevator hoistway in the floor

plan. A systematic fine tuning process is also presented that performs precise, architecturally compatible placement of hoistway(s).

In another article, P. Markos and A. Dentsoras [5] evolve the previous work and introduce a method that determines the optimum position of the elevator system in a multi-storey commercial building considering all the floors of the building. For that, all the floors are partitioned into cells by the same grid, and advanced architectural data (shape and size of structural intrusions etc.) and circulation data (population density of each space, daily demand for elevator service that occupants of a certain usable space present) are correlated for the formulation of an index that demonstrates the intensity of elevator use presented in every cell of each floor. The values of that index are used in weighted Euclidean normes and a low-computational-cost modified Hill Climbing search algorithm retrieves the cell of the building, that presents the minimum weighted mean distance from all the cells that belong to every usable space of every floor. The *x,y* horizontal coordinates that correspond to this cell, represent the optimum coordinates where the center of the horizontal section of the hoistway must be located.

The present paper is based on the aformentioned work is used and proposes a new method that takes into account the floor's circulation paths. The method correlates architectural and circulation data of a typical floor of a commercial building for the definition of the position of the elevator hoistway which is the closest to the point that presents the minimum mean walking distance from/to the entrances of all usable spaces and belongs exclusively to that paths. Additional architectural data such as the posittition of each usable space's entrance and position, connectivity and length of circulation paths are also used. Here, the index of intensity of elevator use refers to every distinguished usable area as a function of the circulation data that characterize that area. The examined floor is partitioned into cells and appropriate matrices are formulated for the identification and description of floor's circulation paths. A modified Hill Climbing search algorithm is used for the definition of the optimum cell that belongs to circulation paths and presents the minimal walking distance from/to all the entrances of usable spaces. Finally, a hoistway design algorithm that combines simple architectural rules and a modified Tabu Search algorithm is applied for the architecturally compatible placement of the elevator's hoistway near to the optimum cell.

2. PRESENTATION OF THE METHOD

2.1 Floor plan and partition grid

Consider the typical floor of a multi-storey commercial building shown in figure 1. In that floor, seven types of spaces and elements can be distinguished according to their use.

a. usable areas (surfaces in figure with the respective legend)

b. circulation areas (surfaces without any legend)

c. atriums (surface with the legend atrium)

d. other spaces like facilities, machinery rooms etc. called as other spaces (hatched surfaces)

e. walls and other structural intrusions

f. entrances of usable spaces

g. circulation paths (consisted of nodes and lines all numbered in figure 1)

Consider now an orthogonal grid G that covers and partitions the surface of the floor. This grid is defined by x- and y- axes, whose point (0,0) corresponds to the lower left point of the floor plan. Grid G partitions the floor plan into square cells, each one's location is given as $c(x, y)$ where x and y are the coordinates of the cell's lower left corner. The grid resolution must be as adequate, so that every cell belongs to only one of the aforementioned surface or element types. The numbered circulation lines of the floor can be represented also by cells as long as the (x, y) coordinates of the latter are simultaneously points of the circulation lines. If S is the entire set of the grid cells, then the cells of usable spaces belong to subset S_U, the cells of circulation spaces (but not those on the circulation lines) belong to subset S_C, and subset S_A refers to the atrium's cells. Subset S_O refers to cells that belong to other spaces (facilities etc.) and S_{SE} is the set of the cells the structural elements consist of. Cells which represent circulation lines compose the subset S_{CL}. Finally, entrances of usable spaces are represented by cells which belong to subset S_{UE}.

The fact that each cell belongs to only one type of space or element, permits the formulation of a matrix of which each element corresponds uniquely to every single cell. This matrix is called Cell Identity Matrix (abbr. CIM) and its size is f × g, where f equals to the maximum floor dimension in y- axis (d_y) divided by the number of grid resolution (gr). Similarly, g equals to the maximum floor dimension in x- axis (d_x) divided by gr. In present paper, gr is equal to 0.1, which means that the dimension of the size of each square grid cell is 0.1 m.

The correspondence between x, y coordinates of a cell and the (CIM) vectors of the respective element of (CIM) is represented by the following two equations:

$$i = (d_y - y)/gr \ (1)$$

$$j = x/gr + 1 \ (2)$$

Every element $CIM(i, j)$ has a value according to where the cell belongs to. More specificaly, if a cell $c(x, y)$ belongs to subset S_U, the element of the matrix that corresponds to that cell takes the value 1, if the cell belongs to S_C the respective value is 2 and S_{SE}, S_O, S_A, and S_{UE} correspond to 0, 3, 4, 5 respectively. The cells $c(x, y)$ whose coordinates are points of a circulation line, take as value in the respective elements of (CIM) the number of the line they belong.

2.2 Elevator Utilization Intensity Index

A usable subspace S_U of a typical floor consists of distinctive usable areas $a_1, a_2, ..., a_m$. For a usable area

a_k, where $k = 1,2,...,m$, the index of Intensity of Elevator Utilization $e(k)$ may be defined:

$$e(k) = D(k)R(k) \ (3)$$

where in this function:

- $D(k)$ is the normalized population density of the usable area a_k. In present paper and in order to demonstrate the proposed method, population density data from office buildings in US are used, as they are extensively reported in bibliography [6]. These data are given in table 1 below.

Table 1. Population density in working areas depending on the type of working personnel

Type of working personnel	Population Density (D)		
	(persons/m^2)	(m^2/person)	Normalized
Seniors	0.280	3.50	1.00
Seniors + visitors	0.160	6.00	0.57
Average	0.100	10.0	0.36
Managers	0.050	20.0	0.18
Executive managers	0.033	20.0	0.12

- $R(k)$ is a ratio that defines the daily demand for elevator service that is presented by the occupants and visitors of the usable area a_k, and is calculated by the following equation:

$$R(k) = \frac{c_{mean}(k)}{max\{c_{mean}(1), c_{mean}(2),...,c_{mean}(m)\}} \ (4)$$

where $k = 1,2,...,m$ and $c_{mean}(k)$ is the mean number of elevator calls per day done by the people that work, use or visit usable area a_k and $max\{c_{mean}(1), c_{mean}(2),...,c_{mean}(m)\}$ is the maximum of the mean numbers of elevator calls per day from people of all usable areas of space S_U.

Ratio $R(k)$ is normalized. This implies that for a usable area hosting people that do not use elevators at all the mean value of elevator calls per day is practically zero and so ratio $R(k)$ is zero too. On the other hand, for cells belonging to usable areas with maximum mean values of elevator calls per day, ratio $R(k)$ equals to 1. The normalization of $R(k)$ values is very comfortable when weighted formulations have to be used.

2.3 Calculation and minimization of mean walking distances

In every floor, the placement, size and connection of various circulation areas (corridors, lobbies etc.) formulate circulation paths that occupants and visitors of the floor follow in order to reach the usable spaces and to access the on-floor facilities.

In the present paper, the circulation paths are represented by lines (axes) that belong to circulation spaces (mostly corridors) and bisect the width of each one of them (see figure 1). These lines are connected with nodes which represent the points in circulation paths where intersections and changes in circulation flow direction occur.

Consider that, in a typical floor, the total number of circulation lines is l and the total number of circulation nodes is n. Then, each circulation line cl_p, where $p = 1,2,...,l$, is defined as a line connecting two nodes nod_q, where $q = 1,2,...,n$. It is possible to create a matrix of dimension $l \times 6$, where each row corresponds to a line uniquely and columns show which are the nodes that define the line and their coordinates. This matrix is called Circulation Line Identity Matrix (abbr. $CLIM$) and an example of that matrix formulated for the examined floor is given below.

$$CLIM = \begin{bmatrix} 1 & 17.9 & 4.3 & 2 & 17.9 & 9.4 \\ 2 & 17.9 & 9.4 & 3 & 20.0 & 9.4 \\ \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots \\ 21 & 11.7 & 9.4 & 2 & 17.9 & 9.4 \end{bmatrix}$$

Here, the first row of ($CLIM$) corresponds to circulation line 1 (cl_1) and the element of $CLIM(1,1)$ shows the first node (here nod_1) that defines cl_1, the element $CLIM(1,2)$ reveals the coordinate on x-axes of nod_1 and the element $CLIM(1,3)$ shows the y coordinate of nod_1. In the same way, the element $CLIM(1,4)$ presents the number of the second node (here nod_2) that defines cl_1, $CLIM(1,5)$ shows the coordinate on x-axes of nod_2 and the element $CLIM(1,6)$ shows the y coordinate of nod_2.

It is a trivial task for a commercial CAD tool to measure which is the minimum walking distance from a node nod_q to the entrance of a usable area a_k, following the circulation paths as they are presented in figure 1. So it is possible to create a matrix with size $n \times m$, where n the number of circulation nodes and m the number of usable areas, where the minimum distances from each circulation node to the entrance of every usable area can be written. This matrix is called Node – Entrance Distance Matrix (abbr. $NEDM$) and every row q, where $q = 1,2,...,n$, corresponds uniquely to a node nod_q, while every column k, $k = 1,2,...,m$, is uniquely respective to a usable area a_k. In every element $NEDM(q,k)$ the minimum walking distance, measured by the CAD tool, between the node nod_q and the entrance of the usable area a_k is written. For example in $NEDM(18,3)$ the minimum walking distance between the eighteenth node nod_{18} and the entrance of the third usable area a_3 is written and its value is 44.7 m.

The correlation of (CIM), ($CLIM$) and ($NEDM$) matrices makes possible the calculation of minimum walking distance from a cell $c(x,y)$, that belongs to S_{CL}, to the entrance of every usable area a_k. More specificaly, (CIM) provides the number p of the circulation line cl_p the cell belongs to. Then the p row of ($CLIM$) shows the two circulation nodes that define line cl_p. In order to comprehend the method, assume that the first node is nod_{1cl_p} and the second one is nod_{2cl_p}, with $\{1cl_p, 2cl_p\} = 1,2,...,n$. Additionally,

$(CLIM)$ provides the coordinates of nodes nod_{1cl_p} and nod_{2cl_p}, so it is easy to calculate the distance of the examined cell $c(x,y)$ from nodes nod_{1cl_p} and nod_{2cl_p} that define line cl_p, where the cell belongs, with the use of Euclidean norm. Now, considering a usable area a_k, $(NEDM)$ provides the minimum walking distance from nodes nod_{1cl_p} and nod_{2cl_p} to that areaI by the matrix elements $NEDM(1cl_p,k)$ and $NEDM(2cl_p,k)$ respectively. By choosing the minor value of $NEDM(1cl_p,k)$ and $NEDM(2cl_p,k)$ and adding to it the distance calculated previously between the respective node nod_{1cl_p} or nod_{2cl_p} and the examined cell $c(x,y)$, the minimum walking distance between the cell and the entrance of the usable area a_k is calculated. The multiplication of this distance with the respective value of the Intensity of Elevator Utilization $e(k)$, gives the weighted minimum walking distance between the cell and the area. Eventually, the minimum weighted mean value of all the distances from the examined cell $c(x,y)$ to the entrance of every usable area a_k is given by the norm given below:

$$d(c) = \frac{\sum_{k=1}^m e(k)(min.\,dist.\,from\,c(x,y)to\,a_k\,entrance)}{\sum_{k=1}^m e(k)} \quad (5)$$

More analytically and summarizing the calculations mentioned above, the minimum weighted mean walking distance from a cell $c(x,y)$ of the subspace S_{CL} to the entrance of every usable area a_k is given by the equation:

$$d(c) = \frac{\sum_{k=1}^m e(k)\left(\sqrt{(x_c - x_{nod_q})^2 + (y_c - y_{nod_q})^2} + NEDM(q,k)\right)}{\sum_{k=1}^m e(k)} \quad (6)$$

where:

$NEDM(q,k) = \min\{NEDM(CLIM(p,1),k), NEDM(CLIM(p,4),k),$

$x_{nod_q} = CLIM(p,2)\,if$
$NEDM(CLIM(p,1),k) = \min\{NEDM(CLIM(p,1),k), NEDM(CLIM(p,4),k),$

$x_{nod_q} = CLIM(p,5)\,if$
$NEDM(CLIM(p,4),k) = \min\{NEDM(CLIM(p,1),k), NEDM(CLIM(p,4),k),$

$y_{nod_q} = CLIM(p,3)\,if$
$NEDM(CLIM(p,1),k) = \min\{NEDM(CLIM(p,1),k), NEDM(CLIM(p,4),k),$

and

$y_{nod_q} = CLIM(p,6)\,if$
$NEDM(CLIM(p,4),k) = \min\{NEDM(CLIM(p,1),k), NEDM(CLIM(p,4),k)$

and $p = CIM(i,j)$ which (i,j) are given from equations (1), (2) and the cell coordinates (x,y).

The cell $c(x,y)$ which presents the the minimum weighted mean walking distance $d(c)$ is the cell that corresponds to the optimum point of the circulation paths of the floor. The entrance(s) to the elevator system should be placed at or near this point.

2.4 The search for the optimal solution

For tracking down of the cell that presents the minimum value $d(c)$, the well known search algorithm Hill Climbing (abbr. HC) is used [7]. So, after the definition of a starting cell belonging to subspace S_{CL} and via an iterative process, (HC) follows a search path towards the final solution. The problem with (HC) is that, while it is a search algorithm which can be applied with significantly small computational cost, it has the inherent characteristic to stuck to local minima or maxima in the set of the solutions of a problem. That is why in present approach a modified version of (HC) is used.

The first modification in comparison to the standard (HC) is the application of an extended search frontier as it is described in the last work of P. Markos and A. Dentsoras [5]. According to that, if $c_{cur}(x,y)$ is the current point at a certain state of the solution process, and the dimension of cells' sides is 0.1 m, then, the search frontier must not be restrained to the next one cells around the current, as it is in standard (HC), but there should be at most forty eight (48) cells around it that should be considered as candidates for being visited next. This modification, permits (HC) to overcome local minima that exist cause to jerky changes in the direction of circulation paths.

The second modification introduced in the present paper, is the application of an exhaustive search as an additional part in the beginning of (HC). That exhaustive search aims at the definition of the starting cell from which, (HC) will create the search path towards the final solution. The exhaustive search takes place only for the cells whose x, y coordinates correspond to circulation nodes. From all the cells which are equivalent to the n nodes, the one that represents the minor value $d(c)$, is used as a starting point for the search of (HC). This modification to (HC) is applied, because several tests of the algorithm have shown that if $e(k)$ has similar value for all usable areas, and the latter are symmetrically assigned around the geometrical center of the floor, then in connections of the corridors that are quite distinct from the center of the floor, local minima appear which attract powerfully the convergence of (HC). That is because the architectural and circulation conditions described above, imply the placement of the elevator system near to the center of the floor, as it has been proven in the last paper of of P. Markos and A. Dentsoras [5]. So, although a point in a circulation line near to the center is the optimum, the search path of (HC) towards that, may pass from connections of circulation paths that are far away from the center, where the architectural and circulation data oblige the elevator system to be placed, and stuck to local minimum. Exhaustive search within the cells that correspond to nodes, results to a starting point near the circulation line where the optimum cell is located.

2.5 Application of the elevator system according to architectural design

After the definition of the optimal point of the circulation path near to which the elevator system must be placed, a simple hoistway design algorithm is used for defining the final position of the elevator system's hoistway with respect to constraints imposed by

architectural design issues. The goal is the placement of the elevator hoistway appropriately, so that it is as close as it gets to the optimum cell, while the entrance of the elevator faces the circulation area where the optimum point exists. In the same time the entrance of the elevator and the entrances of usable spaces should not coincide and the area of the hoistway should not overtake area of facilities.

For the implementation of this process, the necessary width of the side of the entrance of the elevator is represented by a line of cells called as c_{hoist}. A modified Tabu Search (abbr. TS) algorithm starts from the optimal cell found from (HC) and then seeks for a cell of a S_{SE} space which, if it is supposed to be the cell in the middle of c_{hoist} line, permits this line to fit in with the cells of a wall and in the same time be adjacent to cells that belong to either S_U or S_A. At the same time, the retrieved cell must present the minimum Euclidean distance from the optimum cell in comparison with other cells of S_{SE} that consist acceptable – from an architectural point of view - position of the hoistway.

The applied (TS) is characterized as modified as it does not create a search path composed with cells [7], but it commits a perimetrical search around the optimal cell found from (HC). In every step of the process, the search frontier is the set of the cells that formulate the perimeter of a square with center the examined cell by the prevous step and sides equal to $a = 2s + 1$, where s is the number of the current step.

Finally, (TS) in present paper does not stop right afterwards it spots a cell that offers an acceptable position of the hoistway, but it continues until it explores all the members of search frontier for the current step of the search process. That happens because, in cases of architectural symmetry, another cell may offer an acceptable position too and have the same distance from the optimal circulation cell (see case 2 in case study). (TS) concludes after presenting all the similarly acceptable solutions of the current search frontier.

3. CASE STUDY

A case study follows, which exemplifies the proposed method for the floor of a commercial building presented in figure 1. Four different cases of $D(k)$ and $R(k)$ values for the usable areas of the floor are tested (see table 1). The first variant demonstrates the case where all usable spaces have the same population density and their occupants present the same demand for elevator service. The second variant describes a floor where the upper side is more dense considering population and its occupants use the elevator system more often. In the third variant transportation demands are more intense at the right area of the floor plan, while, finally, in fourth variant, the usable areas at the down left side gather more population that presents also higher demand for elevator use.

For the demonstration of the presented hoistway design algorithm, it is supposed that a single elvator with a hoistway of 2.2 m depth an 2m width has to be applied in the floor area.

Table 2. Values of $D(k)$ and $R(k)$ for the four different variants tested in case study

Usable Areas k	Variant 1		Variant 2		Variant 3		Variant 4	
	$D(k)$	$R(k)$	$D(k)$	$R(k)$	$D(k)$	$R(k)$	$D(k)$	$R(k)$
1	0.36	1	0.36	0.5	0.36	0.5	1	1
2	0.36	1	0.36	0.5	0.36	0.5	1	1
3	0.36	1	0.36	0.5	0.36	0.5	1	1
4	0.36	1	0.36	0.2	1	1	1	1
5	0.36	1	0.36	0.6	0.36	0.4	1	1
6	0.36	1	0.36	0.4	0.36	0.4	0.36	0.7
7	0.36	1	0.36	0.7	0.36	0.4	0.36	0.5
8	0.36	1	0.57	0.7	0.36	0.5	0.36	0.7
9	0.36	1	1	0.7	0.36	0.7	0.36	0.5
10	0.36	1	1	0.7	0.36	0.7	0.36	0.5
11	0.36	1	0.36	0.5	0.36	0.7	0.36	0.7
12	0.36	1	0.36	0.3	0.36	1	0.36	0.5
13	0.36	1	0.36	0.3	1	1	0.36	0.8
14	0.36	1	0.18	0.1	1	1	0.36	0.4
15	0.36	1	1	1	0.36	0.5	0.36	0.5
16	0.36	1	1	1	0.18	0.2	0.18	0.2
17	0.36	1	1	0.7	0.36	0.8	0.36	0.5

The results from the implementation of the method in these four variants are given in table 3 and illustrated in figure 1.

Table 3. Results from the implementation of the method in the four different variants of case study

Variants	Coordinates of optimal circulation point (m)		Optimum $d(c)$ value (m)	Coordinates of the center of hoistway(s) entrance(s) (m)	
	x	y		x	y
1	11.6	20.4	28.659	12.6	21.6
2	16.2	32.8	17.645	14.2/18.2	30.7
3	47.2	15.5	22.499	45.1	15.5
4	18.0	9.4	21.061	18.0	11.5

The examination of the results shows clearly that the proposed method follows effectively any changes made in population density and elevator use demand of usable areas and concludes to optimum points of the circulation space that represent the minimum horizontal transportation effort, with absolute compliance to general design of circulation space. Additionally, the hoistway design algorithm proposes all the final positions that are equally closest to the optimum circulation points, while they are compatible with the rest architectural design.

4. CONCLUSION

Towards the improvement of the efficiency of vertical transportation services in commercial buildings, the optimization of the position of elevator systems is examined. Within this context, a method is proposed for the definition of the optimum position of an elevator system in x and y axes of a floor, considering the minimization of horizontal distances that the occupants of the floor have to walk from the areas they work to the elevator system. This method correlates architectural and circulation data for the formulation of equations and matrices that demonstrate the need for vertical transportation as also the complex of circulation paths and the general architectural design. Weighted Euclidean norms, modified heuristic search

algorithms and a hoistway design algorithm based on simple architectural rules are used for the fast and reliable finding of optimally accessible and architecturalluy compatible hoistways, whatever the horizontal architectural and circulation conditions are.

It should be noticed that the proposed method has been developed by considering its potential application to various buildings. For that, the used circulation data refer to every type and design of building, while the tools used for the partition and numerical representation of architectural details of a floor can be used in every building case. Additionally, the proposed hoistway design algorithm is an autonomous algorithm which can be further enriched with detailed architectural rules according to the building to which the method is used.

Finally, it must be outlined that the proposed method works as a useful tool at the preliminary architectural design and helps engineers to predict the future circulation conditions of the building and design the analogous elevator system.

Further work is in progress for the implementation of the proposed method in a multi-floor building and for the enrichment of the architectural rules used by the hoistway design algorithm for the final configuration of elevator hoistways.

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ОПТИМАЛНО ПОЗИЦИОНИРАЊЕ ЛИФТОВСКОГ ОКНА У ЗГРАДАМА НА ОСНОВУ УПРОШЋЕНОГ МОДЕЛА ЦИРКУЛАЦИЈЕ

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У модерним вишеспратним зградама, локација лифтова је веома значајна у погледу ефикасности транспорта и једноставности циркулације по спратовима. Овај рад предлаже методу, након поделе типичног спрата пословне зграде мрежом на ћелије, која повезује архитектонске и податке циркулације, за формирање функција и матрица које нумерички описују архитектуру спрата, пројектовање путања кретања и захтев за лифтом у свакој ћелији. Након тога кориштене су Еуклидске норме и измењени хеуристички алгоритам тражења локације окна лифта који одговара постојећем архитектонском решењу а најближи је путањама кретања на том спрату, што представља најкраћу раздаљину од улаза до дестинације. Студија стања приказује ефективност предложене методе.
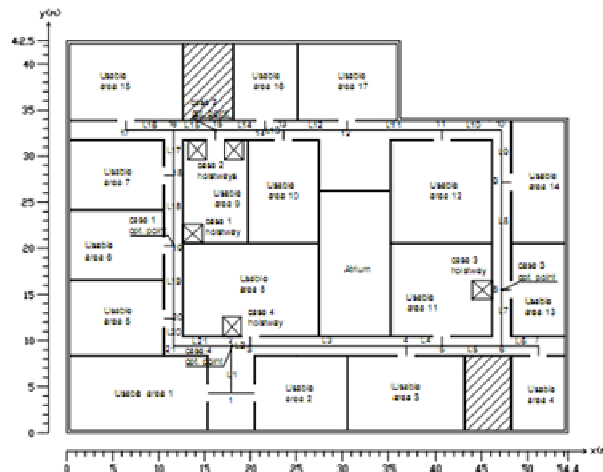
Figure 1. Areas, elements, entrances, circulation paths, lines and nodes of the examined floor and graphical representation of the results by the implementation of the proposed method