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Layout Optimization of Microsatellite Components Using Genetic Algorithm

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Abstract

Placing the components into a container that is normally known as layout optimization problem belongs to NP-hard problems in terms of computational complexity. This study took the layout of microsatellite components as a case study to propose a basic solution strategy for the optimal layout design of a microsatellite. In this case, the layout should meet the requirements of the mission payload, the launcher and the spacecraft attitude control. It utilized the novel scheme to find the various possibilities of optimal layout using genetic algorithm combined with order-based positioning technique. Each component had a given index and then placed in a container based on specific order in accordance with a bottom-left algorithm that was already established. Meanwhile, the placement order was explored by the genetic algorithm to obtain a sequence that brought the best solution. The approach had been validated and proven to produce the optimal layout.

Keywords*: layout optimization, genetic algorithm, microsatellite*

1. Introduction

The problem in making a layout solution is commonly known as a layout optimization problem (LOP), which leads to the non-deterministic polynomial-time hard (NP-hard) in term of computational complexity. LOP is commonly used in engineering applications that pay attention to the physical placement of an instrument or device into a container [1]. Layout optimization is one of the key techniques to improve the performance of a satellite due to a direct impact on the structure, lifetime, cost of assembly, and maintenance of the overall system. Harmonious and reasonable layout is an essential property for the success of the satellite's mission [2]. The layout becomes very critical for microsatellites since it has limitation in space and weight.

As part of the configuration synthesis, the layout of the satellite components should consider the design drivers, attitude control requirements and the allocation of satellite mass and inertia [3]. The design is generally driven by a mission payload and spacecraft launcher. So the research question is how to produce the optimal layout of satellite components that match the requirements of mission payloads, launcher and spacecraft attitude control.

One of the common algorithms to solve the LOP is a genetic algorithm (GA). Shoukun, et al [4] Distinguishes LOP settlement using GA into two methods. The first method is based on the coordinates of the object with a binary or decimal encoding while the second method is based on the order of placement. According simulations and design experiences, the first method often requires a complicated design of fitness function and may be easily trapped in local optimum solution.

The second method combines GA with other algorithms to generate patterns of the placement that overcomes the shortcomings of the first method. GA explores the order of placement to produce the best solution based on a predefined placement algorithm. Recent research generally uses this second method [5-10]. Xu, et al [5] combines the order-based positioning technique (OPT) and GA to obtain the optimal layout of the satellite components. For n ccomponents, there exist $n! = n \times (n-1) \times \cdot\cdot\cdot \times 2 \times 1$ sequences. A genetic algorithm is

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proposed to search this permutation space. In that study, each satellite component is modeled as a circle that is put into a larger circle representing the container.

Modeling satellite component as a circle is less practical in real problems. A satellite component generally has dimensions of length, width and height so it is easier to be represented as cuboid in three-dimensional space or rectangle in two-dimensional space. Therefore, this study uses rectangles in two-dimensional space to simplify a very broad space solution. The combination of GA and OPT will work together to obtain the optimal layout related to the requirements.

To obtain a realistic result, the scope of the study is as the following: (1) The satellite carries out earth observation mission using cameras; (2) The satellite controls its attitude by spin stabilization; (3) The satellite is categorized as a microsatellite class with a maximum dimension of 600mm × 700mm × 800mm so it can make use of the auxiliary payload allocation of the launch vehicle [11].

Since the satellite uses spin stabilization, the spin axis and the major axis of satellite should coincide so the nutation or oscillation effects can be minimized [12]. It means the spacecraft will be stable if it spins in major axis, i.e. the principal axis that has the biggest moment of inertia [13]. The moment of inertia is one measure of the distribution of the mass of an object relative to a given axis, it is equal to mass times the square of perpendicular distance to the rotation axis. The moment of inertia of a composite system is the sum of the moments of inertia of its components which are all taken about the same axis. To fit the aforementioned requirement, the satellite components have to be arranged in such a way that the angle (θ) between the spin axis (ω) and the major axis (I_{max}) is very small or equal to zero, as illustrated in Figure 1.

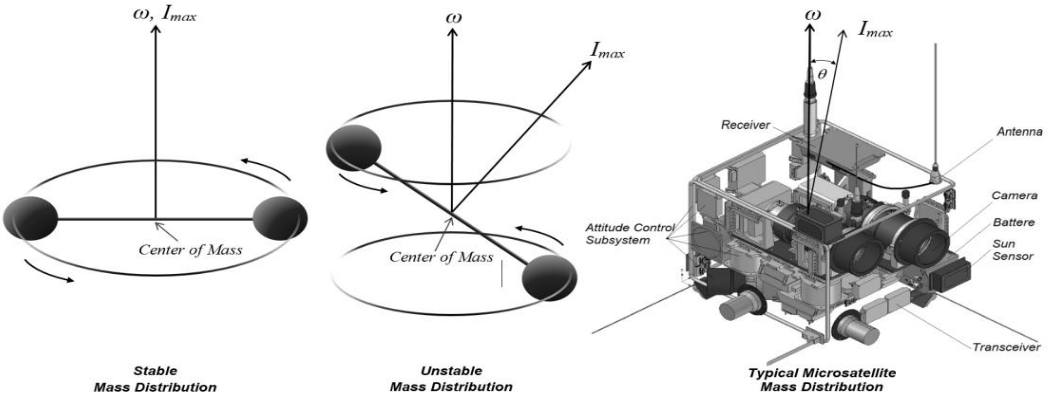


Figure 1. Stability of the Spinning Satellite Related to the Mass Distribution and the Spin Axis

This study aims to arrange the optimal layout of microsatellite components using GA to meet the requirements set by the mission payload, the launcher and the spacecraft attitude control. The layout will take the result from the exploration of more possibilities in the space of solutions. Thus, this research contribution will reduce the dependency of the satellite layout from the intuition of its designer which is ordinarily based on trial and error. The direct effect of the optimal layout is increasing stability of the satellite operation due to balanced mass distribution. Optimal layout would also avoid the use of ballasts to balance the mass distribution of the satellite. It will reduce the entire weight and eventually decrease the launch cost by 10.000 – 100.000 US$ per kg, depending on the launcher [14].

2. Research Method

Microsatellite components layout is established by combining GA and OPT as shown in Figure 2. Each satellite component has a given index to be placed in the container. GA will explore a sequence that produces the best solution based on a predetermined placement algorithm.

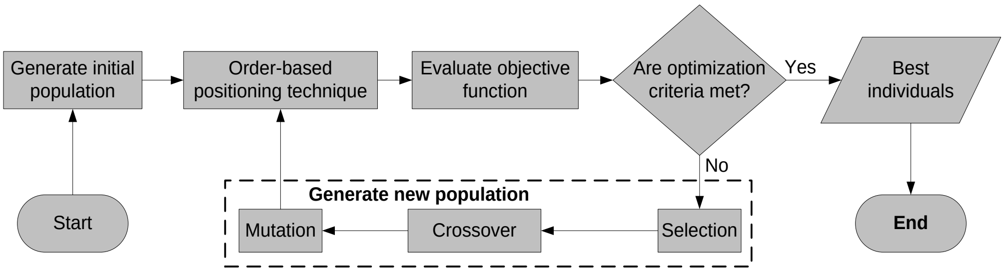


Figure 2. The Combination of GA with OPT

2.1. Order-based Placement Technique (OPT)

OPT generates the layout by establishing a sequence of components, which defines their placement in a specific order. The problem of optimizing the layout of microsatellite components is a combinatorial optimization problem, which is like the traveling salesman problem (TSP). The problem then becomes one of finding the best ordering of components, rather than finding the optimal direct placement of each component. The placement technique has been successfully implemented by Xu, et al [5] for placing of satellite components into its container. Compare to Xu, et al, the OPT in this study would use different of placement algorithm and component model. It will use a cuboid model instead Xu, et al, circle as satellite component.

Since each satellite component is represented as a cuboid, it has length, width, height and mass in the centroid. All these components fill a container plate that consists of the upper and lower surface as illustrated in Figure 3. Placement of components on the container surfaces can be simplified with a two-dimensional approach, i.e. packing rectangle of component into the *x-y* plane in the *xyz* space. The *x-y* plane has a maximum dimension of 600mm × 700mm to meet the requirements of the launcher. Meanwhile, to fulfil the control requirements, the spin axis is set parallel to the *z* axis.

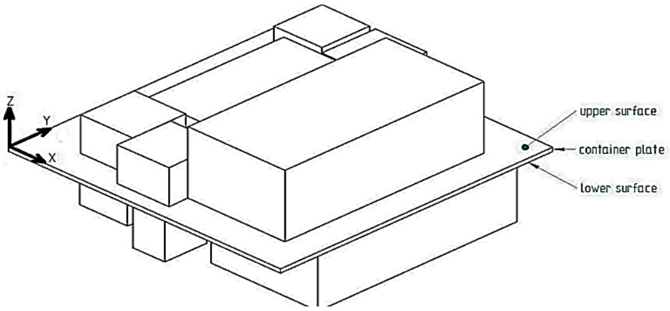


Figure 3. Container Plate of the Satellite Components

In the two-dimensional approach, the number of possible placement configurations of the component is infinite since every movement of a rectangle into a feasible direction creates a new packing pattern. To effectively reduce the number of possible packing patterns, the common OPT so called *Bottom-Left (BL)* condition is often introduced. In BL packing each component is moved as far as possible to the bottom of the container and then as far as possible to the left.

Satellite components sit on both surfaces of the container in accordance with the BL algorithm with a certain order. Baker, et al., [15] introduced the first BL algorithm in 1980. A few years later, Jakobs [16] and Liu and Teng [17] published the new variants of BL. Figure 4 shows the basic movement of those three variants of BL algorithm. The major disadvantage of the latest two variants of BL consists of the creation of empty areas in the layout, when larger items block the movement of successive ones. Regarding to the placement of microsatellite components, the first variant of BL even overcomes the drawback of this placement algorithm. Baker, et al., has developed BL that allows to place each item at the lowest available position of the object with capability of filling existing gaps. That is why Hooper and Turton [18] call also the method used by Baker *et al*. as the *bottom left fill (*BLF). Implementation of these algorithms generally has a computational complexity of $O(n^3)$ in the worst case.

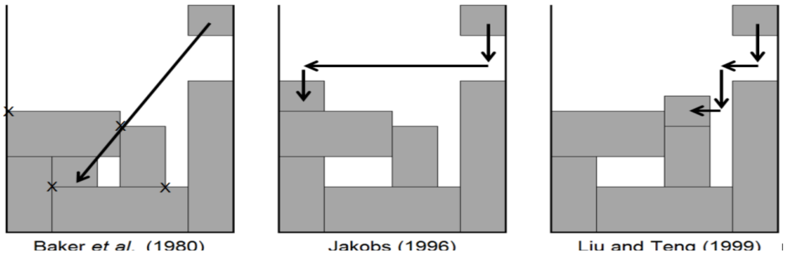


Figure 4. The Basic Movement of the Three Variants of BL Algorithm [19]

Satellite components that are in fixed position such as cameras are always placed at the earliest. This means that if there are *n* cameras, then they will occupy the first to *n* order. The components will fill the upper surface of the container first. If a certain order component could no more fill the upper surface, the rest of the components are placed on the lower surface which is located 10 mm below the upper surface.

2.2. Genetic Algorithm Implementation

GA is typically a robust search and optimization technique. It starts with an initial population with a fitness or objective function calculated for each member of population. If the optimization criteria are met, the best members of the population are considered as solution to the problem. But if the optimization criteria are not reached, population members proceed a selection process where certain members are mated together to produce offspring. The offspring run into a predetermined process of mutation and are then added to the general population. The fitness of the new population is calculated and the process is repeated until the optimization criteria are met.

In this study, GA uses integer encoding to distribute the components of the satellite on the two surfaces of containers. In term of GA representation, each chromosome represents a placement order or layout solution and gene represents a component. Each component represented by gene has index number (i), dimensions of length (l), width (w), height (h) and mass (m) denoted by $p_i = (i, l_i, w_i, h_i, m_i)$. For n number of components, the distribution of n genes is obtained by performing permutation ($1, 2, ..., n$) to represent an individual chromosome, the solution of layout that denoted by $P = (p_1, p_2, ..., p_n)$. Then the number N of individuals are randomly generated to get the initial population.

2.2.1. Objective Function

After all the satellite components have been placed into container using OPT, the objective function calculates the angle between the major axis and the spin axis of the satellite. The angle should be equal or close to zero to meet the requirements of spin attitude control that is obtained by the following stages. First, calculate the center of mass (O_m) of the component distribution using the equation below.

$$O_m = \left(\frac{\sum_{i=1}^{n} m_i x_i}{\sum_{i=1}^{n} m_i}, \frac{\sum_{i=1}^{n} m_i y_i}{\sum_{i=1}^{n} m_i}, \frac{\sum_{i=1}^{n} m_i z_i}{\sum_{i=1}^{n} m_i}\right) \tag{1}$$

Second, calculate the 3 × 3 moment of inertia tensor on its center of mass. Wertz [10] defines the moment of inertia (I) in the coordinate system *x, y, z* in the following equation.

$$I = \begin{bmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{xy} & I_{yy} & I_{yz} \\ I_{xz} & I_{yz} & I_{zz} \end{bmatrix} \qquad (2)$$

Where:

$$I_{xx} = \sum_{i=1}^{n}(y_i^2 + z_i^2)m_i\,;\ I_{yy} = \sum_{i=1}^{n}(x_i^2 + z_i^2)m_i\,;\ I_{zz} = \sum_{i=1}^{n}(x_i^2 + y_i^2)m_i$$

$$I_{xy} = \sum_{i=1}^{n}(x_i.y_i)m_i\,;\ I_{xz} = \sum_{i=1}^{n}(x_i.z_i)m_i\,;\ I_{yz} = \sum_{i=1}^{n}(y_i.z_i)m_i$$

Third, find eigenvalues and eigenvectors based on the obtained moment of inertia. The moment of inertia *I* can be expressed in the form of a diagonal matrix (I_p) by eliminating the product of inertia.

$$I_p = \begin{bmatrix} I_1 & 0 & 0 \\ 0 & I_2 & 0 \\ 0 & 0 & I_3 \end{bmatrix} \qquad (3)$$

The diagonal matrix is known as principal moment of inertia and the corresponding axes are the principal axes [11]. Eigenvalues are the principal moment of inertia (I_p) while eigenvectors (*V*) are the cosine between the reference axes *x*, *y*, and *z* with the principal axes *1*, *2* and *3* so that it satisfy the following equation:

$$I\,V = V\,I_p \qquad (4)$$

Fourth, determine the angle (θ) between the major axis and the satellite spin axis using eigenvectors. If the spin axis is parallel to the *z* axis in the *xyz* coordinate space, the angle between the major axis and the spin axis is arccos of bottom right entry of the eigenvector matrix (v_{33}). GA attempts to minimize θ so the smallest value of θ means the best solution of layout.

2.2.2. Crossover Operator

Crossover should keep the validity of permutations since each gene is distinctive. Assuming from the population that consists of *N* individuals, there are N_i parents selected proportionally based on the fitness value that is also known as roulette wheel selection. N_i is an even number in order to obtain N_i /2 couples. Then each pair performs a crossover operation to produce two offsprings.

Suppose P_i and P_j is a pair of parent solution, then $P_{i\text{-}new}$ and $P_{j\text{-}new}$ are offsprings resulted from crossover operation. For any random number *k*, $1 \leq k \leq n$, the first offspring will take elements 1 ... k of P_i as the first element and take the rest in the same order as revealed by P_j. The second offspring will take 1 ... k elements of P_j as the first element and the rest are arranged in the same order as P_i. For example, if it is known $P_i = \{1, 2, 3, 4, 5, 6, 7\}$ and $P_j = \{7, 6, 5, 4, 3, 2, 1\}$ with $k = 4$, the obtained offsprings are $P_{i\text{-}new}$ = {1, 2, 3, 4, 7, 6, 5} and $P_{j\text{-}new}$ = {7, 6, 5, 4, 1, 2, 3}.

2.2.3. Mutation Operator

If an individual is chosen to perform the mutation, then the two elements position in its series have to be exchanged. The selection process is done randomly. If an individual has *n* genes and there is selected random number *m*, $1 \leq m < n$, then the mutation is done by swapping genes in order of *m* with $m + 1$.

2.2.4. GA parameters and Elitism

The GA is implemented by experiments using the population size of 20, 50 and 100. The probability of crossover (PC) is varied to 80% and 90%, while the probability of mutation (PM) is set at 1%, 5% and 10%. Since there were three variations of the population, two crossover probabilities, and three mutation probabilities, it means 18 combinations of GA parameters needed for statistic test. Each combination should proceed statistic test to determine there are significant differences among the combinations using analysis of variance (ANOVA). If ANOVA found significant differences, the combination of GA parameters that render the best results will be chosen. Many studies have proven that ANOVA could assist best selection of GA parameters [20-21].

Analysis of variance (ANOVA) is developed by statistician and evolutionary biologist Ronald Fisher to analyze the differences among group means and their associated procedures such as "variation" among and between groups. ANOVA is a special form of statistical hypothesis testing generally used in the analysis of experimental data. A test result that calculated from the null hypothesis and the sample is called statistically significant if it is considered unlikely to have occurred by chance, assuming the truth of the null hypothesis.

ANOVA uses F-tests to compare three or more means groups for statistical significance. In one-way or single-factor ANOVA, statistical significance is tested for by comparing the F-statistic. The F-statistic is simply a ratio of two variances. Variances are a measure of dispersion, or how far the data are scattered from the mean. Larger values represent greater dispersion. There are two methods of concluding the ANOVA hypothesis test, both of which produce the same result:

1. The textbook method is to compare the observed value of F with the critical value of F determined from tables. The critical value of F is a function of the degrees of freedom of the numerator and the denominator and the significance level (α). If $F \geq F_{Critical}$, the null hypothesis is rejected.
2. The computer method calculates the probability of a value (*P-value*) of F greater than or equal to the observed value. The null hypothesis is rejected if this probability is less than or equal to the significance level (α).

Aside from aforementioned parameters, the design of GA also implements elitism by retaining two best individuals to be used in the following generation.

3. Results and Analysis

The layout optimization in this study used the specification of LAPAN-A3/IPB microsatellite components as a real case in the satellite development. LAPAN-A3/IPB is a cooperative remote sensing microsatellite project between LAPAN (National Institute of Aeronautics and Space of Indonesia) and IPB (Institut Pertanian Bogor or Bogor Agricultural University) located in Bogor, Indonesia. The demonstration mission of the microsatellite is to monitor food resources in Indonesia and to provide environmental monitoring.

The number of components involved in the process of layout was 28 pieces with a total mass of 38.892 kg as shown in Table 1. This satellite has a mission of earth observation, which means there were components, i.e. cameras that should be placed in a fixed position. Some components had identical mass and shape but different orientations of placement. When referring to the container axes, then all the components were placed with the length (l) parallel to the x axis, the width (w) was parallel to the y axis, and height (h) parallel to the z axis. Each component got an index number to facilitate the randomization of permutation.

Established along the methodology described in the previous discussion, the implementation of layout optimization combined GA with OPT. The 18 combinations of GA parameters have been statistically tested using ANOVA so each combination has performed 30 experiment times with 100 generations. The seed random number generator supplied similar values to every combination test so that they would be statistically comparable. The experimental results along with ANOVA for each combination are shown in Table 2.

The statistical test used the null hypothesis, where there is no real difference between the means of the n combinations. F distribution value in Table 2 was calculated by comparing the variance between groups and the variance within groups. When the F value compared with the $F_{Critical}$, it appears that $F > F_{Critical}$. Furthermore, it also found that *P-value* < α. Therefore, the null hypothesis was rejected. So, through the analysis of variance it was known that the variation of parameters GA provides a significant difference in the results.

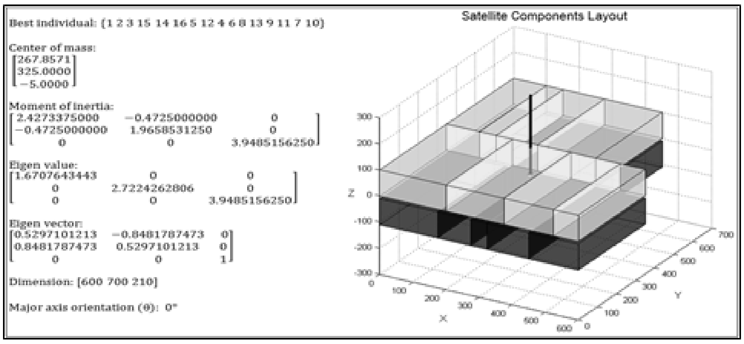
Table 1. List of Satellite Componentsp

No	Component Name	Mass (kg)	Dimension		
			l (mm)	*w* (mm)	*h* (mm)
1	Digital *High Resolution* Camera with 1000mm Focal Length	6.164	199	361	144
2	Scan Imaging Camera with 300mm Focal Length	4.512	176	405	150
3	Video Camera with 100mm Focal Length	0.514	49	171	59
4	Digital Payload Data Handling	1.307	290	192	35
5	Video Recorder	1.206	144	126	52
6	AIS Spaceborne Receiver	0.916	191	118	36
7	AIS Controller	0.443	100	100	25
8	APRS Transceiver	0.618	134	91	52
9	Voice Repeater Transceiver	0.522	65	91	45
10	X-band Payload Transmitter	3.729	192	284	136
11	S-band Payload Transmitter	0.426	66	106	47
12	TTC 1	0.467	65	88	49
13	TTC 2	0.467	65	88	49
14	Power Control & On Board Data Handling	1.671	200	198	54
15	Power Converter	0.387	80	95	30
16	Battery	6.099	215	215	99
17	GPS Receiver	0.327	92	93	38
18	Reaction Wheel 1	1.450	102	105	117
19	Reaction Wheel 2	1.450	105	102	117
20	Reaction Wheel 3	1.450	102	117	105
21	Reaction Wheel 4	1.450	102	117	105
22	Gyro 1	0.133	107	21	65
23	Gyro 2	0.133	21	107	65
24	Gyro 3	0.133	107	65	21
25	Gyro 4	0.133	107	65	21
26	Magnetometer	0.570	214	164	35
27	Star Sensor 1	0.814	100	80	181
28	Star Sensor 2	1.401	100	189	80
	Total Mass	38.892			

Table 2. Single Factor ANOVA of GA Parameters Combination

Groups of GA parameters combination			*Number of Experiment*	*Sum*	*Average*	*Variance*
Population	*PC*	*PM*				
20	0.8	0.01	30	3.6590	0.121967	0.005839
20	0.8	0.05	30	1.1839	0.039463	0.001842
20	0.8	0.10	30	1.0815	0.036050	0.000580
20	0.9	0.01	30	5.1127	0.170423	0.028577
20	0.9	0.05	30	1.9648	0.065493	0.003015
20	0.9	0.10	30	1.1807	0.039357	0.000434
50	0.8	0.01	30	2.1269	0.070897	0.003641
50	0.8	0.05	30	1.4079	0.046930	0.014055
50	0.8	0.10	30	0.6365	0.021217	0.000194
50	0.9	0.01	30	2.9335	0.097783	0.007100
50	0.9	0.05	30	1.0092	0.033640	0.001117
50	0.9	0.10	30	0.4722	0.015740	0.000155
100	0.8	0.01	30	1.5375	0.051250	0.002417
100	0.8	0.05	30	0.7100	0.023667	0.000310
100	0.8	0.10	30	0.4083	0.013610	0.000110
100	0.9	0.01	30	1.2543	0.041810	0.001170
100	0.9	0.05	30	0.8874	0.029580	0.000496
100	0.9	0.10	30	0.4946	0.016487	0.000128
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	$F_{Critical}$
Between Groups	0.866883	17	0.050993	12.895160	2.23E-30	1.642369
Within Groups	2.064217	522	0.003954			
Total	2.931101	539				
Notation: α = 0.05; SS = Sum of Squares; df = degree of freedom; MS = Mean Squares						

The GA parameter with a population of 100, PC 80% and PM 10% has provided the best results so it was chosen for the next GA execution. Nevertheless, this implementation need for validation before used in a real case. The validation performed by placing 16 dummy components that had equal density. The outcome of the optimization was valid since the major axis orientation angle (θ) is equal to zero when the component layout of both upper and lower containers had occupied the same space as depicted in Figure 5.



```
Best individual: (1 2 3 15 14 16 5 12 4 6 8 13 9 11 7 10)

Center of mass:
[267.8571]
[325.0000]
[ -5.0000]

Moment of inertia:
[ 2.4273375000   -0.4725000000   0           ]
[-0.4725000000    1.9658531250   0           ]
[ 0               0              3.9485156250]

Eigen value:
[1.6707643443   0              0           ]
[0              2.7224262806   0           ]
[0              0              3.9485156250]

Eigen vector:
[0.5297101213   -0.8481787473   0]
[0.8481787473    0.5297101213   0]
[0               0              1]

Dimension: [600 700 210]

Major axis orientation (θ):  0°
```

Figure 5. Validation of the Layout Optimization

The layout searching of 28 satellite components was executed within the stopping criteria: max. generation 100, stall generation 60, and fitness limit θ < 0.003°. The stopping criteria were based on Reed *et al.* [22] that relates between population size, convergence rates and genetic drift. This study determined the number of generations (*t*) as follow:

$$2n < t < 1.4N \tag{5}$$

It requires *2n* generations of all individuals within *n* genes to converge. But of *N* population, it should not exceed *1.4N* generations when genetic drift could occur. Genetic drift will cause the GA to converge to a non-optimal solution, a condition that is termed drift stall. Furthermore, the fitness limit (θ < 0.003°) referred to the attitude control resolution. Angle of 0.003° at 505 km altitude of LAPAN-A3 / IPB orbit is equal to about 30 m deviation on the Earth's surface which is still tolerated by the mission. The dynamic process of the layout optimization in a single run is displayed in Figure 6.

The executed result had successfully met all the requirements as shown in Figure 7. The best layout solution obtained very small value of θ, i.e. 0.0014°, while the position of the three cameras is maintained at its initial order and the dimension had not exceeded the maximum envelope that set by the launcher.

To proof the layout is applicable in a real layout design then the optimization result has been implemented in real design using 3D computer aided design, Solid Edge. All the satellite components have been placed precisely in accordance with the position of the resulting layout optimization program. Compared to the optimization program, Solid Edge found very close result of the layout parameter as shown in Figure 8.

This study has provided significant contribution to improve the layout design of the satellite. Compare to the previous generation of LAPAN microsatellite and the other satellite layout model as shown in Table 3, the model of LAPAN-A3/IPB has better layout concerning to the smaller major axis orientation angle.

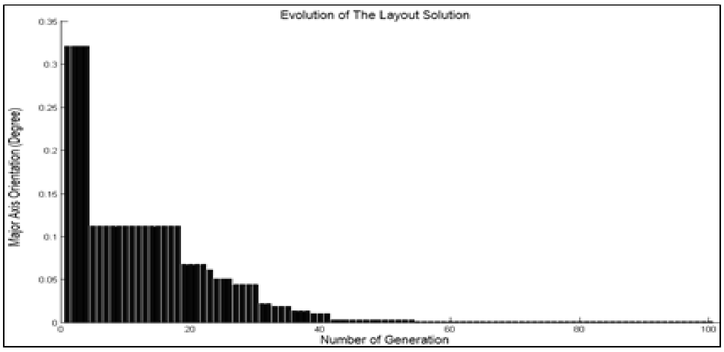
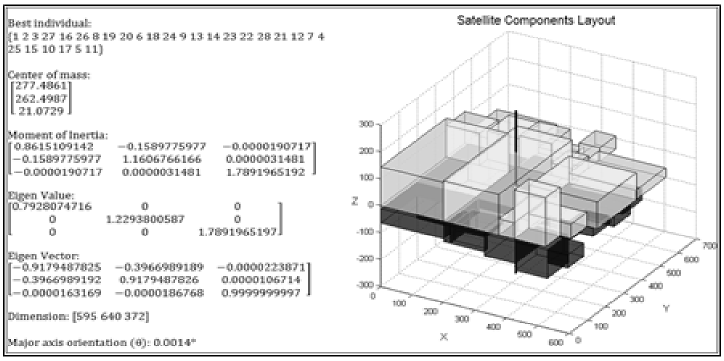
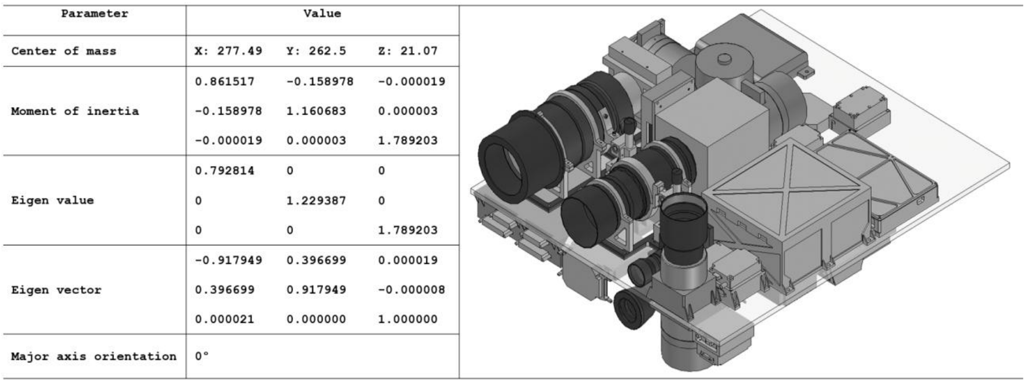


Figure 6. The Dynamic Process of the Layout Optimization



```
Best individual:
[1 2 3 27 16 26 8 19 20 6 18 24 9 13 14 23 22 28 21 12 7 4
25 15 10 17 5 11]

Center of mass:
[277.4861]
[262.4987]
[ 21.0729]

Moment of Inertia:
[ 0.8615109142    −0.1589775977    −0.0000190717]
[−0.1589775977     1.1606766166     0.0000031481]
[−0.0000190717     0.0000031481     1.7891965192]

Eigen Value:
[0.7928074716          0              0          ]
[     0          1.2293800587         0          ]
[     0                0        1.7891965197     ]

Eigen Vector:
[−0.9179487825   −0.3966989189   −0.0000223871]
[−0.3966989192    0.9179487826    0.0000106714]
[−0.0000163169   −0.0000186768    0.9999999997]

Dimension: [595 640 372]

Major axis orientation (θ): 0.0014°
```

Figure 7. Best Solution Result of Satellite Components Layout



Parameter	Value		
Center of mass	X: 277.49	Y: 262.5	Z: 21.07
Moment of inertia	0.861517	-0.158978	-0.000019
	-0.158978	1.160683	0.000003
	-0.000019	0.000003	1.789203
Eigen value	0.792814	0	0
	0	1.229387	0
	0	0	1.789203
Eigen vector	-0.917949	0.396699	0.000019
	0.396699	0.917949	-0.000008
	0.000021	0.000000	1.000000
Major axis orientation	0°		

Figure 8. Implementation the Layout in the Computer Aided Design Software

Table 3. Layout Parameters of Previous Satellite or Model

Satellite or Model	Moment of Inertia (kg.m^2)			Major axis orientation (°)
LAPAN-TUBSAT **[23]**	1.3860	0.0350	0.0630	2.9582
	0.0350	2.0620	-0.0030	
	0.0630	-0.0030	1.4410	
LAPAN-A2/ORARI **[24]**	2.9875	-0.0901	-0.0158	7.6985
	-0.0901	3.6544	-0.0257	
	-0.0158	-0.0257	2.8689	
Model of Sun ZG & Teng HF **[2]**	287.4600	-0.1400	0.2300	1.0939
	-0.1400	295.3300	0.6000	
	0.2300	0.6000	216.0300	

4. Conclusion

The layout of microsatellite components can be optimized using the genetic algorithm combined with order-based positioning technique. The optimal result has met the requirements of the mission payload, the launcher and the spacecraft attitude control. It fulfills the requirements of mission payloads and launch vehicle dimensions by defining the rule of the program while the objective function managed the mass distribution that supports spin stabilization. The optimization has found the best layout solution that is expressed by the angle between the major axis and the spin axis, which is close to zero.

There are several recommendations to improve the quality of the layout solution. The layout optimization can be further developed by putting the center of mass at a certain point for easier installation of launch adapter or by entering specific preferences on the placement of components. To support the aforementioned recommendation, the container may be divided into several pieces and the placement algorithm is modified so that each piece has a different positioning rule. It will lead to better overall positioning of the components.

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