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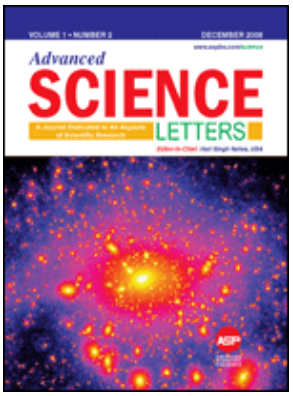

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A Multiple-Objective Ant Colony for Optimizing Disaster Relief Logistics

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(Abstract) A logistic is one of the most important parts of disaster management. Disaster relief logistic must be optimizing with selection short path. Selection path of the logistic is aimed at residential areas close to the volcano and into the danger zone. A logistic disaster needed an information system with accurate and quickly intervening respond. Concerns expressed in the logistic is a less accurate path selection and a complex path that will be chosen so as to result in casualties. This paper tries to investigate to choose the shortest path in the logistics of the eruption of the Lokon volcano. This study tried to apply the formula by entering a speed indicator, distance, bend, density and secure point to calculate the short path to being selected using MO-ACO algorithm. Model simulations and calculations are done by making the aggregation of existing indicators and continue to calculate and determine the short logistic using MO-ACO algorithm. Results obtained to produce a solution with the short path logistic map that is a low budget, and quickly respond to manage disaster. This map became clues in disaster management and navigation in the logistic process. This logistic map using for logistic information system and implicated in disaster management Lokon volcano on North Sulawesi. (Abstract)

Keywords: multiple-objective, ant colony optimization, logistic disaster relief, lokon volcano, short path.

1. INTRODUCTION

In the period 2010-2015 statistics show that natural disasters, especially in Indonesia volcano eruption [1] have occurred 32 times with the result 409 people died, lost four people, injured 2,223 people and 183.345 people displaced. In the northern province of Sulawesi own, in the same period, the statistics show that four people were missing, five people were injured and 1,625 people were displaced by volcanic eruption.

Volcanic eruptions can result in an extremely dangerous condition that needs treatment quickly and precisely. Handling is meant is how governments and societies can manage and access information associated with the eruption of the volcano, mitigation and workarounds such as path selection handlers evacuation and after the eruption. It is intended to reduce casualties. On the other side, the handling of the volcanic eruption is in need of high cost and response time is fast and accurate. That burdens the budget and available resources can be optimally required computational methods and techniques such as the use of algorithms MOACO to perform optimization calculations. Activities that may be made such as determining optimal logistic lines disasters quickly and accurately, easily accessible with a quick time to reach the point of refugee shelters. It is thus important to make path selection strategy based computing technology that can harness models computational algorithms such as Multiple-Objective Ant Colony algorithm as a solution in route selection logistical support disaster.

The problem is the difficulty of choosing the path to distribute disaster relief logistics. It is caused by the complex pathways available and the condition of the area is at an elevation that is steep with narrow lanes and dangerous. This study uses a case study on the mountain Lokon in North Sulawesi, Indonesia. Geographically settlements which are located around the mountain is located on the uplands steep and rugged with narrow lanes and many dangerous bends. The layout of the mountain Lokon located in Tomohon city which became the capital of north Sulawesi. Tomohon area of the city where there are many villages surrounded by the foot of the mountain. This requires good handling and efficient in order to prevent loss correct even many casualties. For it is necessary to study and ways and strategies in dealing with natural disasters. This study tried to resolve these problems by using simulation optimization algorithm Multiple Objective Ant Colony Optimization (MOACO) in determining the distribution channels logistical help in achieving the shortest disaster shelter refugees.

This paper, we try to model logistic shortest path selection, algorithm using MOACO and use some constraints in calculating to obtain a good optimization model and can be implemented.

2. ANT COLONY OPTIMIZATION (ACO)

Ant colony algorithm is built to be inspired in the ants foraging [2]. Shaping algorithm model is primarily ants. Ant Colony is a metaheuristic algorithm that includes branches of Swam Intelligence. Metaheuristic itself a development of the concept of heuristics. This algorithm is very good [3] on calculations using the independent variables to produce an optimal solution. Metaheuristic algorithm allows optimal approach in a short time so as to produce the optimal solution strategy (et al). Ant Colony Optimization algorithm (ACO) [3] is the best of the existing ant colony variants. ACO has a relative calculation [4] result approaching the optimum. ACO algorithm can be a reference to the implementation in natural disaster mitigation issues [5], especially the eruption of volcanoes such as the evacuation route selection quickly. Ant Colony Optimization algorithm (ACO) can be used in the selection of the best lane in evacuation easily and quickly.

ACO algorithms constructed with construction candidate [6] to get a combination of optimization problems. ACO begins to provide solutions that are still empty as intended originally. Then added to the solution components to obtain a more thorough candidate solutions and optimal. In a single objective, ACO called as QAP [6], defined as the solution components to the facility marks a location [7]. To undertake the construction solutions such steps is repeated until the determination of the neighborhood to be empty so that a complete solution can be calculated. After the finished solution is constructed, pheromone then updated. Performance evaporation seen with the first drop pheromone trails with a constant factor [8] ant then allowed to deposit pheromone on the solutions that have been constructed.

Thus ACO applied in mitigation path in the following manner: Thus spake ACO applied in mitigation path in the following manner: First, construct a problem into a graph G = (V, E) with vertex set V representing the set point - the point and E is the set of edges that represent the distance between two points. Secondly, there are constraints on the evacuation route that is visiting n points with points that there is only visited once by the same starting point to the end point. The objective of the shortest path selection, logistics shortest path and determining the point of shelter is looking for the shortest tour of the n points Third, scoring the intensity of a trail of ants (Pheromone) and heuristic information. Scoring Pheromone (rs τ) in the evacuation path do when ants visit s point after visiting the point r. Heuristics information (rs η) is information that represents the quality of an edge between the point and the point r s, this information is computed before the algorithm is executed. With rs d η = 1, rs d r is the distance between the point and the point s. Fourth, (tour construction). A tour is built by applying a simple procedure as follows: Initialization placed m ants in n points according to certain rules, and then apply the state transition rule ants iteratively. Ants build tracks as follows. At the point r, ants choose the probabilistic point s unvisited by intensity Pheromone (rs τ) on the edge of the point r to point s, as well as the existing local heuristic information, namely the long side (edge). Ant probabilistically prefers point are close and connected with a high level of Pheromone. To build the shortest path possible, each ant has a form of memory called tabu list. Tabu list is used to determine the set of points that still must visit at each step and to ensure the establishment of the shortest path possible. Besides the ants can trace back its trajectory, when a track was completed. After all, ants build a tour, Pheromone is updated by reducing the rate Pheromone by a constant factor and then put the ants on the edge that is passed Pheromone. The update is done such that the edge of the track is shorter and pass a lot of ants receive Pheromone amount to more. Therefore, in the next iteration of the algorithm will have a higher probability to be selected.

3. MULTIPLE-OBJEVTIVE ANT COLONY OPTIMIZATION (MOACO)

When calculating with many objects, the algorithm used is Multiple Objective Ant Colony Optimization (MOACOs) [9]. MOACOs this algorithm begins with multi algorithms two objects and two pheromones. Thus there is two similarities function to be counted. The equation of the form BIANT [10] (Bi-Criterion Ant), MOACS [11] (Multi-Objective Ant Colony System) and CHAC [9] (Compan~ı'a de Hormigas ACorazadas). MOACOs [12] algorithm can be used to solve the problem of TSP. In fact, MOACOs algorithm is widely used to solve optimization problems with bi-objective TSP (Traveling Salesman Problem). The use of this approach can be made by combining two ant colony algorithm [13] MAX-MIN Ant System (MMAS) and ACO. This approach is almost the same as MOACOs, but used in solving problems in the TSP.

Basically, algorithm MOACO adds a number of components into an algorithm metaheuristic ACO algorithm by connecting into the multi-objective problem [10]. At MOACO any information pheromone is assumed, that the MOACO algorithm using multi pheromone information [11], which has the distinction that defines the object and its weight so that it becomes a single value. This value is equal to the weight used in calculating the aggregate object in the scale of the multi-objective problem [6].

To get the best performance ACO, pheromone update strategy used single colony is done by selecting the best solution [11] or the best bit of the solution set of the current iteration, or since the algorithm starts (best so far strategy). Pheromone dominant [10] and recommended to be used as a strategy that will be used. In the multi-colony, pheromone update strategy in doing, similar to the strategy used in a single colony. To run specialize colony, every deposit pheromone is used only for one colony alone [6] [8] [11]. Selection of pheromone been the dominant method adapted straightforwardly in a multi-colony. This refers to the use of ant Pareto candidate sets obtained from the distribution of the ant colony and are allowed to deposit pheromone [11].

There MOACO framework created by Manuel Lopez. There are 9 functions are available and can be used. In this study, the framework used to solve problems in the shortest path selection path selection disaster relief logistics.

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4. PROBLEM DESCRIPTION

In a volcanic eruption disaster management, logistics desperately need the support of various organizations and government. It is concerned with how to regulate the movement of staff, equipment, and material assistance to reach the disaster site through a prescribed path. The path is taken to be a short, fast and secure so that it can be reached safely. As we know, the delivery of logistical support to the disaster point should be reached at the right time and the right place.

Distribution channels barely passable with many obstacles requires sought the right path to follow. From the literature, which can be obtained in the optimization models to choose the shortest path can be reached disaster point quickly and precisely. In easy to calculate, then we perform the division based on the position supply logistic materials. This segment is divided into four segments, each segment supplying logistical support to the nearest evacuation point.

In this paper, the area to be mapped the distribution channels help logistic a disaster area who need help quickly. The area consists of four villages prone to disasters and disaster management priority. The following figure 1 can explain the area to be mapped:

Figure 1. Map area disaster Lokon volcano North Sulawesi

In this section, we describe in part develop to calculate the shortest path optimization. To calculate using algorithms MOACO by adding constraints to modify MOACO equation [14]. This is done to try to find the best solution in the shortest path searches for path disaster relief logistics. Constraints are distance, speed, a number of bends (curve), the density and the number of secured points. Constraints will be in matrix information pheromone as an aggregation.

5. A MOACO MODELING

A. Assumption

In the paper, we make some assumptions that can be used in the calculation algorithm MOACO:

1) Distance, measured in unit km (kilometers). This variable is the distance between nodes designated and declared distance to go in across nodes. MOACO algorithm will calculate the best distance and the closest that must be passed up to the point that secure logistics shelter refugees. This distance is one important variable in the use of this MOACO algorithms.
2) The speed, measured in units km/h (kilometers per hour). Variable declared average speeds that can be reached within a distance of nodes. This speed is the average speed that is accumulated regardless of other considerations such as the bend and the many obstacles faced. This algorithm tries to select a good speed in choosing logistic distribution channels that must be passed.
3) Curve, measured in units of the number of twists. It states how many hurdles faced by a path. The more twists contained in a path, then the speed will be reduced in the evacuation and affect the performance of the evacuation process in general. MOACO algorithm will choose the path that curves less to determine the logistic distribution channels that must be passed.
4) Density, the measure of the amount of exposure of a track. This variable counting the number of people and the level of density that can lead to stagnation of a pathway that may be passed, so it can hinder the speed and effectiveness in the process of distribution logistics. MOACO algorithm will choose the path that the level of low-density so that the speed and effectiveness of the evacuation would be better
5) Secure point, the measure of the number of points to be traversed secured on a track. These secure spots obtained from the disaster map provided then be a determined path that many secure point level. These algorithms incorporate MOACO secure point in the calculation so that the path chosen should completely secure for traveling. MOACO algorithm will choose the path that points secure much so secure to be passed from the disaster itself. It is intended that the logistic distribution process, no casualties occurred during the process of food distribution logistics and food distribution logistics process itself can be easily known by the people especially those affected by the eruption of the volcano.

In this paper, we use and adopt the framework MOACO [8] algorithm, with constant parameters as follows:

TABLE 1. MOACO ALGORITHM CONSTANT PARAMETERS SETTING

Parameter	Value
N^a	24.[η/100]
ρ	0.02 (η < 300), 0.05 (η ≥ 300)
q_0	0
α	1
β	2

Then to do the calculations, we perform the configuration of the components used in accordance with the framework set MOACO algorithm automatically namely:

TABLE 2. AUTOMATICALLY MOACO ALGORITHM FRAMEWORK COMPONENT

Component	Domain	Constraint
[τ]	{single, multiple}	
[η]	{single, multiple}	
Aggregation	{weighted sum, weighted product, random}	Only if multiple τ or η
N^{weight}	{2,3,N^a/3, N^a/2, N^a}	(per colony)
NextWeight	{one weight per iteration, all weight per iteration}	
pheromoneUpdate	{ND, BO, BOW*}	* only with N^{col} = 1
N^{upd} N^{col}	{1, 2, 5, 10}	
MultiColony Weights	{1, 2, 3, 5, 10}	
MultiColony Update	{disjoint, overlapping}	Only if N^{col} > 1
	{origin, region}	Only if N^{col} > 1

B. Equations

To determine the heuristic information aggregation to our equations used in the algorithm of MOACO framework that identifies three alternatives as follows:

Weighted sum :

$$\tau_{ij} = (1-\lambda)\tau_{ij}^{k} + \lambda\tau_{ij}^{s} \quad and \quad \eta_{ij} = (1-\lambda)\eta_{ij}^{k} + \lambda\eta_{ij}^{s} \quad (1)$$

Weighted product :

$$\tau_{ij} = \left(\tau_{ij}^{k}\right)^{(1-\lambda)}.\left(\tau_{ij}^{s}\right)^{\lambda} \quad and \quad \eta_{ij} = \left(\eta_{ij}^{k}\right)^{(1-\lambda)}.\left(\eta_{ij}^{s}\right)^{\lambda}. \quad (2)$$

Random :

At every step of development, given a uniform random number U (0, 1), ants choose the first of two matrices if U (0, 1) <1 - λ; besides choosing other matrices.

In three aggregation methods Described above, there are weight λ being the aggregation bias towards one objective or the other. Set of weights Λ defined by components $N^{weights}$ and NextWeight.

$N^{weights}$ dan NextWeight. The set weight is defined in the interval [0, 1] as

$$\Lambda = \{\lambda_i = 1 - (i-1)/N^{weights} - 1),\ i = 1, \ldots, N^{weights}\}$$

Where $N^{weights} = |\Lambda|$ are the parameters of the framework.

The equation used to determine partial solution would be to follow the probability to calculate the pheromone by the following equation:

$$p_{sj}^{k} = \frac{\left[\prod_{q=1}^{q}\left(\tau_{s_q j}^{q}\right)^{\lambda q}\right]^{\beta}}{\left(\left[\prod_{q=1}^{q}\left(\tau_{s_q l}^{q}\right)^{\lambda q}\right]^{\alpha}.\left[\prod_{q=1}^{q}\left(\eta_{s_q l}^{q}\right)^{\lambda q}\right]^{\beta}\right)} \quad if\ j \in N_s^k \quad (3)$$

To calculate we use the automatically MOACO framework [11]. This framework works by using a variety of options available to obtain optimal results in its calculations.

C. Steps to use MOACO

To be able to use MOACO algorithms performed using the following steps:

Setting parameters, this step is done by setting the parameter information pheromone, a component r, n, aggregation methods and iterations are performed.

Local search, this step is done by doing a local search technique by calculating all the points you've visited and established the shortest paths to be used.

Update pheromone, this step is done by selecting the track in the pheromone update strategy nondominated solution, best-of-objective, and best-of-objective-per-weight.

MOACO algorithms are used, follow the algorithm can be explained by the algorithm MOACO in figure 2 below:

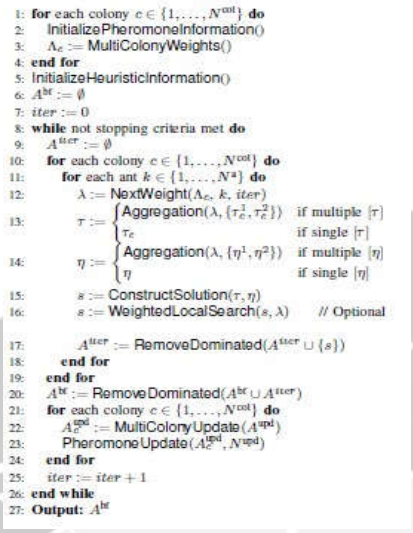

Figure 2. Framework MOACO Algorithm

To be able to calculate the MOACO algorithm applied to the affected area. The disaster area is the area of the eruption of Mount Lokon located in Tomohon, North Sulawesi. The condition of the segment area can be seen in the following table 3 below:

TABLE 3. CONTAINS COMPONENTS USED

Route	Distance	The speed	Curve	Density	Secure point
Segment I	7	4.33	4	7	4
Segment II	14	3.33	8	10	8
Segment III	11	3.08	4	8	7
Segment IV	12	2.75	2	6	8

To be able to calculate, a map of the area is converted into four segments that will be counted. The segment can be described as figure 3 follows:

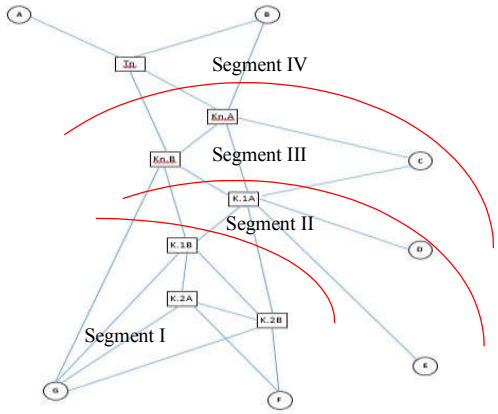

Figure 3. Segment in determining the distribution area of relief logistic

6. COMPUTER RESULTS AND DISCUSSION

In this section, we implemented the MOACO algorithm to obtain the best results. The data we use comes from Badan Penanggulangan Bencana Daerah (BPBD) Kota Tomohon North Sulawesi and in accordance with actual conditions. The real data is the data obtained specifically for the case of the eruption of Lokon volcano. We collected data at intervals ranging from 20th May to 16th August 2016. The data were collected by direct observation in the affected areas and the eruption of the data obtained from the records BPBD during the period 2010-2015. The data we get is a complex data so that we make the four segments of the logistics distribution area in order to facilitate the calculation. We expect the divided segment area to facilitate the calculation is the best result. To execute the time required we used the CPU time method. To explain the gap that occurs between the weighted sum of objective value and the ideal value is called Vmoy, we use the equation:

$$V_{moy} - \frac{\sum_{i=0}^{p=1} \lambda_i (f_i - f_i^*)}{\sum^{p=1} \lambda} \quad (4)$$

ρ = Objectives Number (p = 7).

λi = objective with priority i weight = (p- i + 1).

fi = objective with priority i value.

fi*= objective of priority i ideal value, obtained by minimization of this objective under the rigid constraints.

%Im = Initial solution percentage improvement

$$\%Im = \frac{Vmoy(Sol.Insiatif - Vmoy(Sol.Finale)}{Vmoy(sol.Initiatif)} \quad (5)$$

Results

We having five runs for experiments and fixed α value. That α is 1 and proved it's a best value. Then we selecting β value where we defined. After that, we having five runs, we having defines the β value as optimal value and take it to same other parameters with some procedure where defined. We make as a problem as example to the short path.

The final solution is obtained using by quality and execution time terms, generating a feasible approach to logistic map. To obtain quality solutions, we carry out the first stage aims to deliver a uniform shortage or surplus. This first stage we use the way of diversification adopted in the algorithm, then we use ant colony beginning of each ant from different colonies with other ant colonies for a solution. Objectives related to each solution colonies beginning any ants from different colonies from one colony to another colony very calculated. In determining the initial solution of a colony, a maximum number of iterations needed to increase the available solutions. The number of iterations does not exceed one hundred iterations, and also have an impact on the reduction of the computation time. The proposed method should allow having a good speed so as to allow for planning to run a large number of test sets. Predefined criteria associated with these colonies determined to get a good and proper solution.

From the calculation using MOACO algorithm, it can be seen that the shortest path how the first segment I by 95%, then the segment IV by 84% and the latter is the segment II and III by 81%. It is hinted that in doing logistical support area segments I and IV can be reached quickly while segments II and III need time to reach the area. Result of map with MOACO algorithm

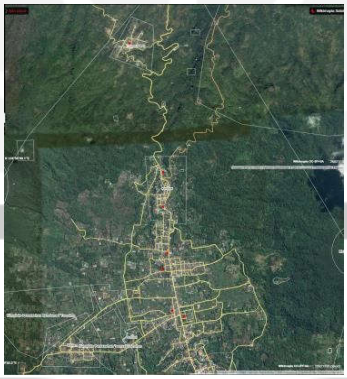

Figure 4. Map disaster relief logistic at Lokon volcano

7. CONLUSION:

The results shortest path using algorithm Multiple-Objective Ant Colony Optimization (MOACO) can be used to find the shortest path and alternate path based on certain criteria (distance route, speed, curve, density and secure point) in the process of disaster relief logistics. Based on these test results the search, the system will ignore the criteria of importance (weight) is small or zero. Decision making is the shortest path and alternate path by the criteria of distance route, speed, curve, density and secure point, depending on the weight values entered during the rank process, preference value. The first will be selected as the shortest path and preference value the second will be selected as alternate path.

Implementation of the MOACO algorithm can solve the problem of selecting the shortest path in disaster relief logistics. There are several ways to choose a strategy to get the right solution in determining the number of colony algorithm parameters and the number of pheromone structure. This paper discusses only one variant discussed of this algorithm on real instances of the short path disaster relief logistic problem; this algorithm very effectiveness to tested in a limited population. This paper are recommended to use a large population with other variants to generate solutions as good quality as the MOACO algorithm within a sufficiently reasonable time.

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