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Research paper

Distribution System for Urban Agricultural Products Using Genetic Algorithms based on Android

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Abstract

Urban agriculture is an agricultural activity (farming and cultivation) inside the city. Urban agriculture generally produces fruits and vegetables that have a short shelf life. Urban agricultural activities include production, distribution and marketing of agricultural products. Efficient distribution's routes are highly needed for better delivery of agricultural products to customers. Failure in route selection could increase shipping and operating costs, and also could reduce the product's quality. Itt is necessary to obtain the right route to distribute products that could reduce operational costs and maintain the quality of product until the destination. This research develops an application to determine the distribution route for urban agricultural products using genetic algorithms. This application can calculate the optimal distribution route so that in the process of distribution of urban agricultural products can be done accurately and efficiently. Route optimization with genetic algorithms successfully optimizes the best route, and can be seen from the fitness value that continues to increase each generation

Keywords: *VRP, Distributin System, Urban Farming, Genetic Algorithm.*

1. Introduction

Urban farming is agricultural activities inside the city in the cultivation and processing of food. The concept of urban farming is to utilize unused land in urban areas and convert it into green productive agricultural land. Urban farming activities include production, distribution, and marketing of agricultural products. Agricultural productions must be distributed through appropriate and efficient routes. Errors in route selection can result in shipping delays and greater operational costs and can reduce product quality.

Designing the right distribution system can result in significant cost savings for the company. The cost could be reduced by combining several product distributions for several customers into several integrated routes. Operational and planning problems related to the distribution of goods are influenced by several factors such as the area coverage, transportation costs and the time needed for transportation. The objective of effective product distribution is to minimizing some distribution targets by assuming all routes, the vehicle must depart and return to the facility center (Christofides et al., 1979).

The problem to minimize the route of distribution of goods with limited vehicle capacity is called the Vehicle Routing Problem (VRP). VRP resolves the problem of a set of routes for a number of transport fleets or vehicles that depart and return to a predetermined point that must be distributed to serve several customers.

Many methods are used in solving this VRP problem, one of them is Genetic Algorithm. Genetic Algorithms are a search procedure based on the mechanism of natural selection and natural genetics that can be used to solve difficult combinatorial optimization problems. Genetic Algorithm was introduced by John Holland and researchers from the University of Michigan, in 1976. Genetic Algorithms were chosen because Genetic Algorithms do not have specific criteria found in other heuristic algorithms in filtering the quality of solutions, therefore computing time is also relatively shorter, and can produce several alternative solutions that have the same objective value.

With the background of the problems described above, an application will be developed to optimize the distribution of urban agriculture using genetic algorithms on mobile devices by utilizing google map.

2. Related Work

2.1. Previous Research

Urban Farming is activities to produce agricultural products inside the city. carried out in urban areas. The main challenge of urban agriculture is the limited land, so that efficiency measures ranging from planting schedules, compatibility between production and market demand, to the product distribution process need to be done to get maximum profit. Almost all urban farming products have very short shelf-life as fruit and vegetable. Urban farming product must be distributed through appropriate and efficient routes. Errors in route selection can result in shipping delays, large operating costs and it can reduce product quality.

Several previous studies using the VRP method, among others, were carried out by Saputri, Mahmudi and Ratnawati [10] who applied genetic algorithms with the application of VRP on the distribution of instant noodles to designated stores. The activity of distributing begins with vehicles that already contain cargo from the designated warehouse. Then the vehicle containing the cargo will begin the journey from the warehouse to the designated shops. The problem that often arises when shipping is the route taken in order to optimize travel time. Many vehicles are operated and distributions can reach the specified time.

Rayandra Yala Pratama & Wayan Firdaus Mahmudy (14) also developed Optimization Of Vehicle Routing Problem With Time Window (VRPTW) for food product distribution using Genetics Algorithm. The results show that the best population size is 300, 3,000 generations, the combination of crossover and mutation rate is 0.4:0.6 and the best selection method is elitist selection.

Dita Sundariningsih (15) developed the Application of Genetic Algorithms for Vehicle Routing Optimization Problem with Time Window (VRPTW) Case Study of Bottled Drinking Water.

Based on some of these references, this research develops the application of optimization of urban agricultural distribution using genetic algorithms on mobile devices by utilizing google map.

2.2. Vehicle Routing Problem

Vehicle Routing Problem (VRP) is a range of problems in which there are a number of routes for a number of vehicles. The purpose of VRP is to deliver goods to consumers with a minimum cost through the routes of vehicles in and out of a point called the depot [1]. In its development, VRP has several types in its application, including:

a. Capacited Vehicle Routing Problem (CVRP), with the main factor being that each vehicle has a certain capacity.
b. Vehicle Routing Problem with Time Windows (VRPTW), is a type of VRP with vehicle capacity constraints and time windows for each customer and depot.
c. Multiple Depot Vehicle Routing Problem (MDVRP), is a type of VRP that has many depots in service to customers.
d. Vehicle Routing Problem with Pick-Up and Delivering (VRPPD), with the main factor being that the customer / customer may return the item to the original agent. Research (Montane & Galvao, 2006) uses Tabu Search algorithm where VRP-SPD is one variation of classical VRP. Delivery of goods is supplied from one depot at the starting point of delivery, while pick-up of cargo is then taken to be returned to the depot. The characteristic of VRPSPD is that the vehicle used on a route is filled with the cargo of goods shipped and the cargo of pick-up.
e. Split Delivery Vehicle Routing Problem (SDVRP), is a variation of capacitated vehicle routing problem (CVRP) where service to customers is carried out using different vehicles.
f. Periodic Vehicle Routing Problem (PVRP), with the main factor being delivery is only done on certain days. The purpose of this PVRP is to minimize the total route distance and complete the problem of determining customer service schedules.

g. Variations of all VRPs can be used according to conditions with the aim of minimizing the total mileage to get the minimum transportation costs

2.3. Genetic Algorithm

Genetic Algorithm (GA) is a heuristic method to find the optimum solution of a problem by using a search mechanism that mimics the process of biological evolution. The mechanism used is a combination of random and structured search. This algorithm has been successfully applied in various combinatorial problems, ranging from Traveling Salesman Problem (TSP), VRP, and production scheduling.

Compared to others heuristic algorithms, Genetic Algorithm has different approach to determine the optimum combination. In general, the heuristic method looks for the optimum solution by arranging combinations in stages based on certain selection criteria and iteration terminations. The is only one solution. In contrast, the Genetic Algorithm makes a genetic code of the combination in question, better known as the gene term (genotype) which is further enhanced by iterations that resemble natural processes in reducing genetic traits. Therefore, Genetic Algorithms do not require specific criteria found in other heuristic algorithms in filtering the quality of solutions or reducing computation time and can produce several alternative solutions that have the same objective function values

3. System Design

This research develops applications to optimizing the distribution path of urban agricultural products. This system is divided into two, web-based and mobile-based systems. Web-based systems as a backend that functions in product management, product orders and supply management. Android-based systems are used to find optimal paths in the distribution of agricultural products. general description of the system can be seen in the figure below.

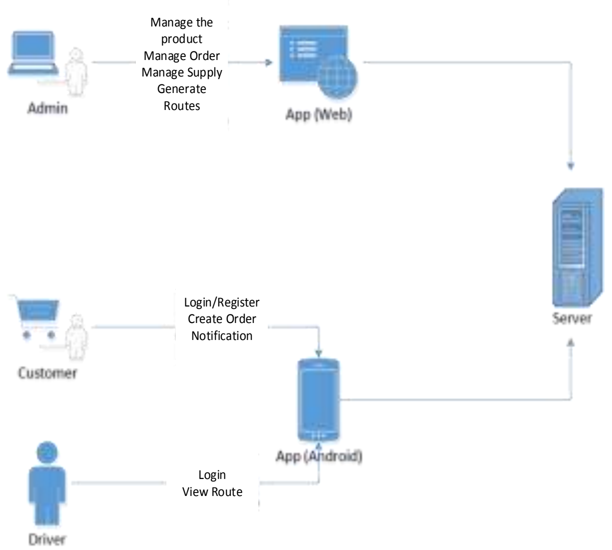

Fig 1: System Design

There are 3 actors in the system, Admin, Driver and Customer. Drivers and customers can only log in through the Android application, while the admin can only log in through the web application. Customers can buy products on the Android application, when making a purchase, the customer must enter a shipping address and take latitude and longitude coordinates on Google Maps. Then the application will do the best route search process with GA algorithm, the distance between location parameters will be dynamically optimized by applying the Genetic Algorithm. The distance parameter between locations is the gene for each chromosome. The criteria for termination of the optimization process is that the genetic algorithm will stop after reaching the specified number of generations. Optimization algorithm with Genetic Algorithm, can be seen in the figure below

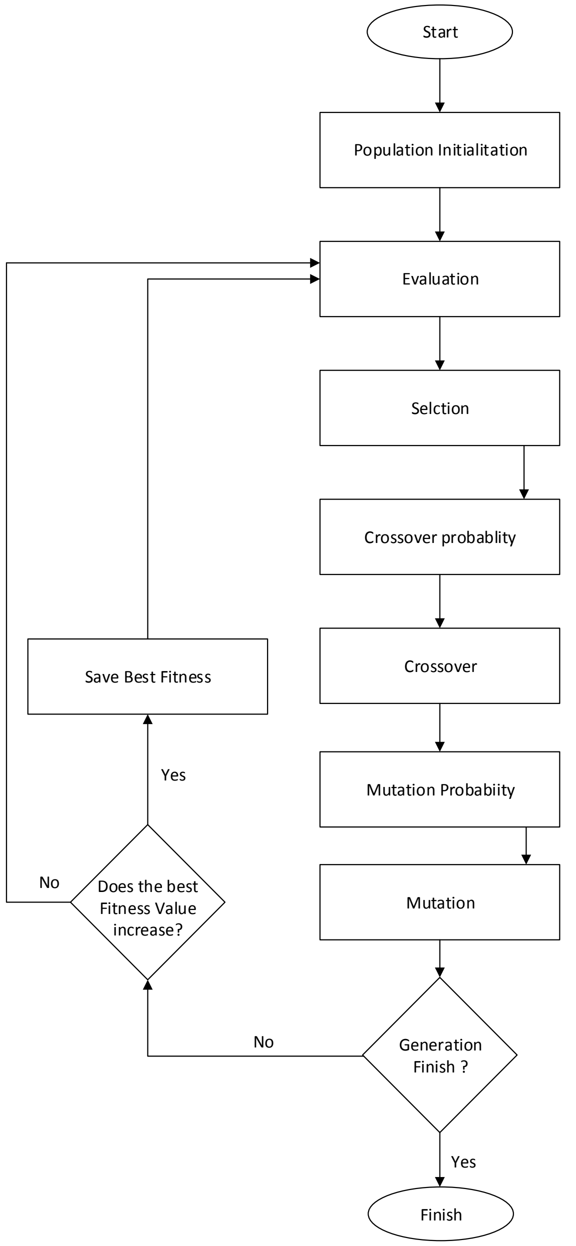

Fig 2: Optimation Process

The stages for optimizing with the Genetic Algorithm are as follows:

a. At the beginning of genetic algorithms process, initial population initialization is needed, at this stage the number of chromosomes raised in a population is determined. This initial population is generated randomly so that the initial solution is obtained.
b. Evaluation of the initial population is done by calculating the distance between locations. The distance data is used as a fitness value for the initial population,
c. Selection is done by using the roulette wheel selection method, using this selection method based on the probability of each chromosome. The size of the proportion of chromosomes in the roulette wheel will vary depending on the fitness value of the chromosome. The selection is done by generating random values from the range of the sums of all fitness,
d. Crossover is done with a crossover order to produce offspring, crossover is not always done because it has a predetermined probability at the beginning. Random values are generated from the range 0 to 1, if the random value is smaller or equal to the crossover probability value (Pc) then the crossover is done,
e. Mutation is done by exchange mutation, the process of mutation is done by replacing one randomly selected gene with a new value that is obtained randomly. Mutations are not always done because they have a mutation probability (Pm),
f. Re-selection is done by elitism method, to get the best 5 populations to be used as a population in the next generation,
g. Chromosome generation index added 1,
h. The optimization process is done to get the most optimal results up to the predetermined generation index
i. Chromosomes with the best fitness values are displayed.

4. Result

The testing process is conducted to evaluate the system's behavior and to find out whether the system can generate routes optimally. Route optimization testing is carried out using the following order data.

Table 1: Testing Generate Optimum Routes

No	Order Number	Address
1.	51	7Â°22'02.2"S 112Â°43'49.9"E Jl. Gajah Mada No.3, Krajan Kulon, Waru, Kabupaten Sidoarjo, Jawa Timur 61256, Indonesia
2.	52	Jl. Bulak Banteng Wetan III No.6, RT.000/RW.00, Sidotopo Wetan, Kenjeran, Kota SBY, Jawa Timur 60128, Indonesia
3.	53	Jl. Kupang Krajan VIII No.29, RT.007/RW.04, Kupang Krajan, Kec. Sawahan, Kota SBY, Jawa Timur 60253, Indonesia
4.	54	Jl. Kebonsari Tengah No.28-A, RT.007/RW.01, Kebonsari, Jambangan, Kota SBY, Jawa Timur 60233, Indonesia
5.	55	Jl. Rungkut Industri III No.52, Rungkut Menanggal, Gn. Anyar, Kota SBY, Jawa Timur 60293, Indonesia
6.	56	Intiland Tower, Jl. Panglima Sudirman No.101, RT.011/RW.07, Embong Kaliasin, Genteng, Kota SBY, Jawa Timur 60271, Indonesia
7.	57	Jalan Gardenia, Sukomanunggal, Suko Manunggal, Kota SBY, Jawa Timur 60188, Indonesia
8.	58	Jl. Ps. Siap No.38, RT.001/RW.04, Komp. Kenjeran, Bulak, Kota SBY, Jawa Timur 60121, Indonesia

From these data testing was carried out with a population number = 15, crossover probability = 0.75, mutation probability = 0.25 and number of generations = 50. From the test results obtained the most optimum route was Depot-52-58-55-51-54-57-53- 56-Depot with a total distance of 42.70 Km and fitness history as follows:

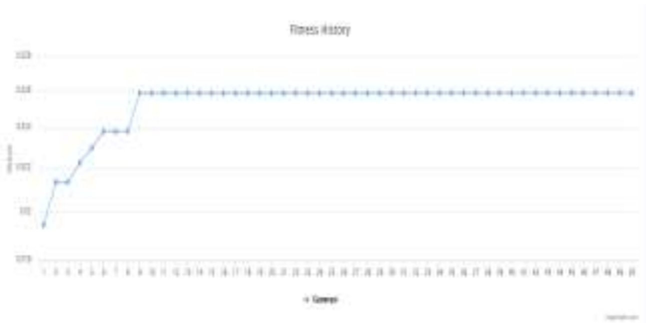

Fig 3: Fitness History from Testing Generate Optimum Routes

It could be seen from the graph above that from the 10th to 50th generation, the fitness value does not increase since it has reached the optimum point in the 9th generation. From this test it can be concluded that the system is able to produce optimum routes. It can be seen from the increase in fitness value of each generation. Figure 4. is a route displayed on the google maps

Fig 4: Result Routes

To find out how well the system's performance, it tested by comparing the speed and results of system calculations with manual calculation. The testing method is carried out as follows:

1. The calculation of the system is done once, with 10 generations,
2. Manual calculation is done using Microsoft Excel application, initial population is inputted manually based on user assumptions.

The experiment using the order data in Table 2, produce calculation in in Table 3.

Table 2: Order Data For Testing Genetic Algorithms

No.	Order number	Address
1.	18	Jl. Dharmahusada Permai Blok v No.109, Mulyorejo, Kota SBY, Jawa Timur 60115, Indonesia
2.	17	Bund. Waru, Dukuh Menanggal, Gayungan, Kota SBY, Jawa Timur 60234, Indonesia
3.	15	Jl. Raya Tenggilis Mejoyo No.87, Kali Rungkut, Rungkut, Kota SBY, Jawa Timur 60292, Indonesia
4.	14	Jl. Kedondong Kidul I No.74, Tegalsari, Kota SBY, Jawa Timur 60262, Indonesia
5.	13	Jl. Kalijudan Indah No.39, Kalijudan, Mulyorejo, Kota SBY, Jawa Timur 60114, Indonesia

Table 3 is the result of the experiment using the order data in table 2.

Table 3: Best Fitness Value Calculation of Each Generation System

Generation	*Fitness Value*
1	0.041882
2	0.042373
3	0.042373
4	0.042373
5	0.042373
6	0.042373
7	0.042373
8	0.042373
9	0.042373
10	0.042373

to determine the performance of genetic algorithms, the results of the application are compared with manual calculations as in Figure 4

Tabel 4: The Best Fitness Value for Each Generation Manual Calculation

Generation	*Fitness Value*
1	0.036487452
2	0.036487452
3	0.036487452

From the experiment's result above can be concluded that the application of optimization is very helpful in finding the most optimum route, by using system calculations in the second generation has shown an increase in fitness value. While using manual calculations, the fitness value does not show an increase.

To determine the performance of the system, it is tested by comparing the population. Tests carried out with a population of 5, 10, 15, 20 and 25 with a combination of crossover probability = 0.75 and mutation probability = 0.25 and number of generations = 50. To get the average fitness score, each experiment was carried out 5 times . Tests are carried out in the following order table:

Table 5: Second experiment data *order*

No	Order Number	Address
1.	51	7Â°22'02.2"S 112Â°43'49.9"E Jl. Gajah Mada No.3, Krajan Kulon, Waru, Kabupaten Sidoarjo, Jawa Timur 61256, Indonesia
2.	52	Jl. Bulak Banteng Wetan III No.6, RT.000/RW.00, Sidotopo Wetan, Kenjeran, Kota SBY, Jawa Timur 60128, Indonesia
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8.	58	Jl. Ps. Siap No.38, RT.001/RW.04, Komp. Kenjeran, Bulak, Kota SBY, Jawa Timur 60121, Indonesia

The experiment results can be seen in table 6.

Table 6: The experiment results of the Effect of Population Amount on Fitness Value

Number of Population	Fitness Value					average
	1	2	3	4	5	
5	0.02391	0.02467	0.02467	0.02683	0.02467	0.02495
10	0.02403	0.02400	0.02391	0.02456	0.02683	0.02467
15	0.02683	0.02400	0.02691	0.02542	0.02683	0.02600
20	0.02554	0.02587	0.02587	0.02489	0.02542	0.02552
25	0.02691	0.02542	0.02345	0.02451	0.02345	0.02475

The test's results as seen in table 6 above are then visualized into graphs as follows:

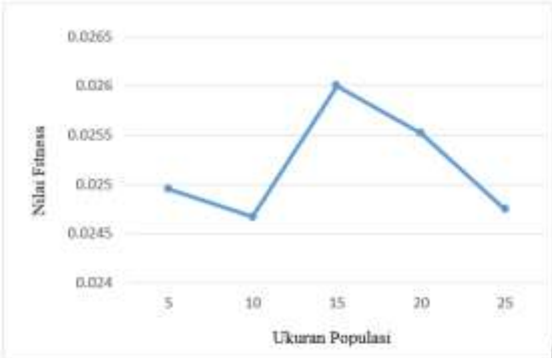

Fig 5: Experiment Results of Population Amount of Fitness Value

As seen on the Fig. 5, the average fitness value experienced a decrease after population size at 25.. We also found that the size of the population that is too small or too large will not produce optimal solutions. It is happen since the population's size that is too small caused the exploration area become too wide, thus the opportunity to get the best solution is smaller. While when the population's size that is too large causes the exploration area become narrower, allowing convergence and long computation time. Narrow exploration causes the search for best solution can not work properly and the child that produces the fitness value is almost the same as it's parent

5. Conclusion

The conclusions obtained after designing, developing, testing and analyzing this research are as follows:

1. The calculation of genetic algorithms in this application could produces better route compared to the manual calculatio, it can be seen from the best fitness value produced.
2. The number of populations affects the fitness value produced by a genetic algorithm, the size of the population that is too small or too large will not produce optimal solutions.

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