Newton's Method for Distance Optimization in Firefly Algorithm in Determining Optimum Nutrition for Laying Hens

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Abstract

An accurate calculation of feed nutrition and more affordable price is an extremely complex. Firefly algorithm is an algorithm designed for optimization calculation whose output is highly dependent on light intensity (β), which is influenced by distance (r). Therefore, in order to produce maximum output values, an optimization of firefly distance should be done. The most appropriate method is Newton's Method as it has the capability of solving roots of equations accurately. From the testing of distance optimization in firefly algorithm, a fairly good increase in the fitness value was obtained.

Keywords: *Newton Method, Firefly Algorithm*

1. Introduction

In determining the composition of the feed material is very a complex calculation. Because it must consider all the nutrient content in the feed material in accordance with the age of animals, especially laying hens. And also required fast and accurate computation so that decisions can be taken immediately. For that we need a computational algorithm that is able to complete the optimization calculation of the dosage of feed ingredients, quickly and accurately.

The firefly algorithm is an algorithm created to find the optimal solution [1]. The advantage of the firefly algorithm is that the best generated generation will be the reference to change the light intensity or the quality of the solution, so that when the changes in the solution is not far from the best solution. So that the required computation iteration more efficiently.

Setiawan, et al [2]. Using the firefly algorithm to do the scheduling, and get a small enough penalty of 0.0003. Hadhi, et al [3]. Use the firefly algorithm for scheduling the power plant unit. By obtaining a low enough cost below 2% the firefly algorithm is considered reliable in terms of optimization of power plant scheduling.

The distance between firefly individuals is the most vital element in the firefly algorithm. This is because the firefly algorithm uses light intensity in changing the value of each individual that is considered poor [1]. Meanwhile, the level of light intensity between fireflies is highly influenced by distance. The shorter the distance of the firefly, the stronger the level of light intensity.

With regard to laying hen feed, firefly algorithm is used for the optimization of the best amount of feed in accordance to the required nutrition and the minimum price. Ini this algorithm process, 15-35 [1] initial solutions are given randomly, which are also called the initial inviduals, which represents a number of feed types. Then, a change in every individual is made in order to be closer to the ideal or fitness value.

Newton's Method is one of the best methods used for obtaining maximum optimization of square roots [4]. Newton's Method uses approach repetition to obtain the value that is the closet to the real value. The distance between fireflies is calculated by finding the square root of the difference between the value of the best individual and the value of the poorest individual. The optimization process is done by obtaining the optimum square root value by doing some iteration so that the optimum result is obtained, then it is used as the value of the distance between individuals.

In the previous research, Ismail et al [5] used Newton's Method for the optimization of genetic algorithm in solving nonlinear equations, in which new individuals are going to be selected and the ones that have values close to nonlinear value will be maintained. As for the individuals whose values are far from the nonlinear value will be changed using Newton's approach. The result shows a better accuacy level compared to the previous research. Farook and Raju [6] in their resarch optimized individuals in firefly using Genetic Algorithm, in which the best individual will be crossed over to poorer individuals. The results obtained are the global solution that have even fitness and good fitness value.

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In this research, only distance optimization is going to be carried out as firefly algorithm has a number of complex parameters for finding optimal solutions. Thus, the merging of methods that have complex parameters such as genetic algorithm will add more computation load in the calculation. In this research, the method of addition is going to be done as efficient as possible to maximize the computatin in firefly algorithm.

2. Newton's method

Newton's method is an approach method for finding the valu of the roots of equations. It is expressed in the following equation [7]:
Following linear algebra equation

$$f(x) = 0 \qquad (1)$$

From the equation above, the tangent point is $(x_0, f(x_0))$ = f ' (x_0) the tangent equation is 0 - f(x_0) = f ' (x_0) (x - x_0) and they are intersecting on x axis when y=0. Thus, 0 – f(x_0) = f ' (x_0) (x - x_0) and x_1 = x = x_0 - $\frac{f(x_0)}{f'(x_0)}$ if x_2 = x_1 - $\frac{f(x_1)}{f'(x_1)}$. It is started from x_2 if x_2. Jika x_3 = $\frac{f(x_2)}{f'(x_2)}$. Therefore, the following equation is obtained

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} \qquad (2)$$

If the equation above is used in solving the equation f(x) = x^2 - 5 and f '(x) = 2x, the following is obtained

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} = x_n - \frac{{x_n}^2-5}{2x_n} = \frac{2{x_n}^2-({x_n}^2-5)}{2x_n} = \frac{{x_n}^2+5}{2x_n} = \frac{1}{2}\left(x_n + \frac{5}{x_n}\right)$$

thus, the simplest equation obtained from Newton's method is

$$x_{n+1} = \frac{1}{2}\left(x_n + \frac{5}{x_n}\right) \qquad (3)$$

3. Firefly algorithm

By adopting the behavior of fireflies and the way fireflies flash, in 2007-2008, Xin-Sheyang developed firefly algorithm under the following rules [1]:

a. Fireflies have unisex nature so the attraction to others is not based on the sex.
b. The attraction toward others is influenced by the brightness level of fireflies' flash. In a wide distance, the brightness decreases, so the fireflies that have less brightness will approach those brighter. The fireflies will move to any direction or randomly if there is no bighter light.
c. The light of the fireflies is determined by the objective condiction and function to determine the level of brightness.

The attraction of fireflies is determined by the brightness perceived by the fireflies nearby. Thus, the formula of attractiveness β can be expressed

$$\beta = \beta_0 e^{-\gamma r^2} \qquad (4)$$

β_0 = attractiveness at r = 0.
γ = The coefficient of light absorption, which controls the light decrease.

$$r_{ij} = \| x_i - x_j \| = \sqrt{\sum_{k=1}^{d} (x_{i,k} - x_{j,k})^2} \qquad (5)$$

$x_i - x_j$ = the distance between two fireflies
x_{ik} = component to k from the spatial coordinate x_i from firefly i.

$$x_i^{t+1} = x_i^t + \beta_0 e^{-\gamma r^2} (x_j^t - x_i^t) + \alpha_t \varepsilon^t \qquad (6)$$

x_i^t = the initial position of firefly i.
$\beta_0 e^{-\gamma r_{i,j}^2} (x^t{}_j - x^t i)$ = attractiveness.
$\alpha_t \varepsilon^t$ = the firefly's random movement. α is a random number from 0 to 1

$$x_i^{t+1} = x_i^t + \beta_0 \; e^{-\gamma r^2} \; (x_j^t - x_j^t) \; + \; \alpha_t \varepsilon^t.$$

We substitute the formula for finding the distance with Newton's method formula.

$$r_{ij} = \| x_i - x_j \| = x_{n+1} = \frac{1}{2}\left(x_n + \frac{r_j}{x_n}\right) \qquad (7)$$

4. Laying hen feed

The feed inside hen's body has several functions as [8]:

a. Constituent substance (building substance) is the constituent substance that builds the body structure of hens, including protein, mineral, fat and water.
b. Energy substance is the energy source producing heat, work and/or accumulation of fat such as carbohydrate, fat, protein.
c. Regulating substance as the substance controling the function inside fowl body, including vitamins, enzimes, hormones, minerals, certain amino acids and certain fat acids.
d. Additional function is a function used for producing something such as egg and milk.

Tabel 1. Nutritional needs of laying hen [9] (*ISA Nutrition Menegement Guide , 2010. ** SNI,1995)

	Age (Week)					
NUTRITION	**0-4**	**>4-10**	**>10-16**	**>16 – Egg Production 2%**	**Egg Production 2% - 28**	**28 - Afkir**
Water Content (%)**	**<14**	**<14**	**<14**	**<14**	**<14**	**<14**
Energy Metabolism (kkal/kg)*	**2.980**	**2.850**	**2.750**	**2.750**	**2.75**	**2.75**
Crude Protein (%)*	**20,5**	**20**	**16,8**	**17,5**	**18**	**17**
Crude Fiber (%)**	**< 6,5**	**< 7**	**< 7**	**< 7**	**< 7**	**< 7**
Crude Fat (%)**	**2,5 - 7**	**2,5 – 7**	**2,5 - 7**	**2,5 - 7**	**3,5 – 3,7**	**2,5 - 7**
Ash (%)**	**5 - 8**	**5 – 8**	**5 - 8**	**10 - 14**	**10 - 14**	**10 - 14**
Calcium (%)*	**1,05–1,1**	**1 - 1,2**	**1 – 1,2**	**2,0 – 2,1**	**3,25 - 4**	**3,6 - 4**
Phosphor (%)*	**0,48**	**0,44**	**0,40**	**0,47**	**0,40**	**0,33-0,37**

Every feed is differentiated based on the feed substance content and adjusted to the age of the laying hends. The followings is the table of nutritional need of laying hens.

5. Distance optimization in firefly algorithm

In phases, firefly algorithm is described as follows:

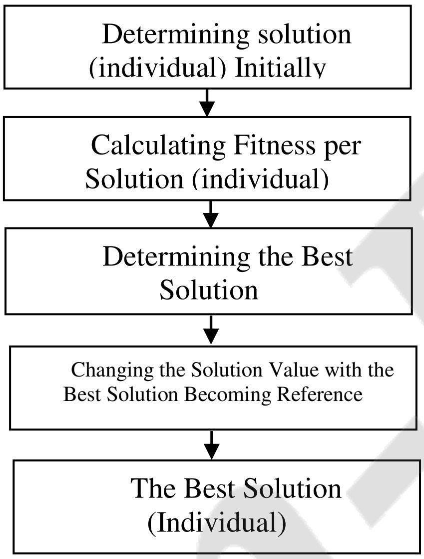

Figure 1. The phases of firefly algorithm to find the best solution

The fourth phase, which is changing the value, is done using firefle algorithm formula, which is

Thus, for the 4th phase, changing value can be done through some stages, namely:

Stage 1. Taking the best firefly to be made the reference of distance from other fireflies.

Stage 2. Finding the value distance by reducing the best value with the value of other fireflies.

Stage 3. Distance optimization using Newton's mtehod and doing iteration until the distance between the initial solution and the final solution approaches or has the value of 0 so the best distance is obtained.

Tabel 2. Analysis of the raw material of laying hen feed [10]

Raw Material	ME (Kcal/kg)	Crude Protein (%)	Crude Fat (%)	Crude Figer (%)	Ash (%)	Calcium (%)	Phosphor (%)	Water Content (%)
Yellow Corn	3.360	9,0	4,1	2,2	24	0,3	50	15
Buckwheat	3.040	11,0	1,9	3,4	1,65	0,028	0,28	16
Broken Rice	3.050	8,9	2,0	1,0		0	0	1,36
Mill Fine Bran	1.630	13,6	8,2	8,0	10,8	0	0	14,5
Traditional Fine Bran	2.240	41,7	4,0	6,2	10,8	0	0	14,5
Peanut Meal	2.200	43,9	6,0	12,6	0	0,2	0,65	6,6
Coconut Cake	1.540	20,5	6,7	12,0	6,36	0,08	0,52	0
Fish Flour	2.910	61,8	7,8	0,6	7,19	0	1,01	0
Meat Flour	2.150	57,80	10,2	1,7	0	0	0	0
Shrimp Flour	2.900	33,20	4,4	18,3	0	0	0	0
White Leadtree Leaf Flour	1.140	23,20	2,4	20,1	7,79	0	0	0
Vegetable Hummingbird Leaf Flour	1.230	31,7	1,9	22,4	0	0	0	0
Papaya Leaf Flour	1.230	23,50	9,1	11,3	0	0	0	0

This is illustrated in the flowchart below:

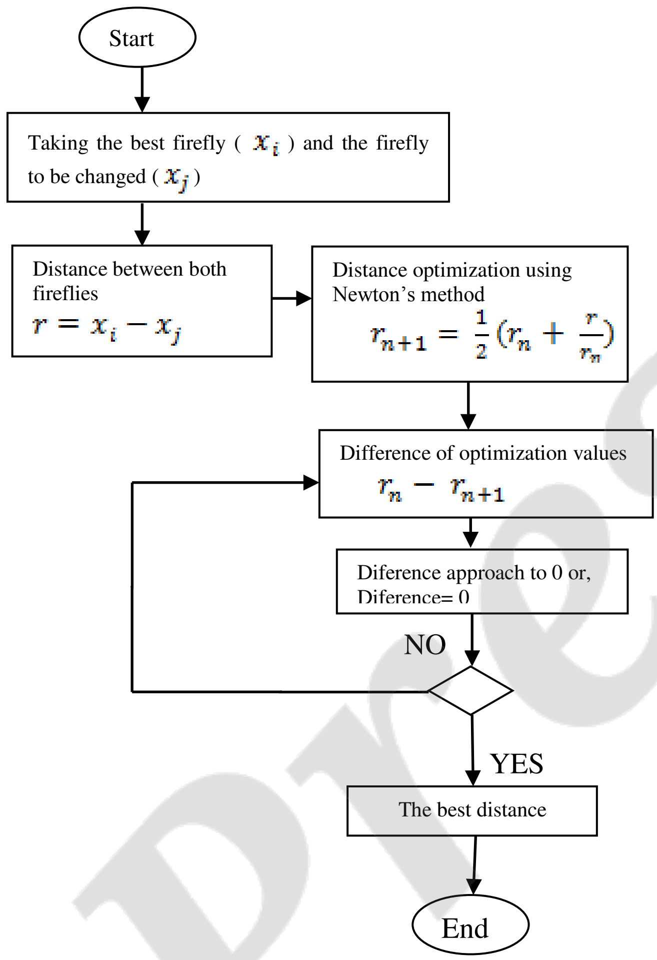

Figure 2. The flowchart of Newton's method in determining the optimum distance in firefly algorithm.

6. Testing result

There were several phases used in this study. The first phase was testing the number of optimum fireflies, and the number of iteration = 100. After the number of optimum fireflies was obtained, the movement value (β), light coefficient (γ) and random value (α) were obtained. The testing was compared to the fitness. The higher the fitness, the closer the solution to be optimum. Based on this testing, the Newton's method was then applied and the best iteration was tested.

In the testing of the number of fireflies, 15 to 40 fireflies were tested. By using 6 feed combinations, the best fitness was obtained when the number of fireflies used was 35. This is shown in the table below.

Table 3. Testing of the number of fireflies

Number of Firefly	β	γ	α	Fitness
15	1	0,2	-1	0,961
20	1	-0,2	-1	1
25	1	0,8	-1	0,985
30	1	1	-1	0,930
35	1	1	-1	0,960
40	1	-0,2	-1	1

$$\text{Fitness} = \frac{1}{\text{Nutrition value} - \text{Nutrition standart}} + \frac{1}{\text{Row Material (Kg) x Cost (Rp/Kg)}} \quad (8)$$

According to the results of the testing, it was found out that the best numbers of fireflies based on the highest fitness value were 20 and 40. The number of fireflies of 20 was selected due to lighter computation.

The next phase was testing the number of iteration in the Newton's method. In the testing, 10-80 iterations were conducted by using 4 feed combinations20 firefly algorithm iterations, β value = 1. γ = -0,2. α = -1.

Table 4. Ptesting of the number of iterations in Newton's method

Jumlah Iterasi	Best 1	Best 2	Deference
10	9,620	9,580	0,040
20	9.0142723769946	9.0000112987902	0,014
30	9	9	0
40	9	9	0
50	9	9	0

The optimum number of iterations is 30+ iterations. Therefore, the number of iterations in the Newton's method in this research was 30.

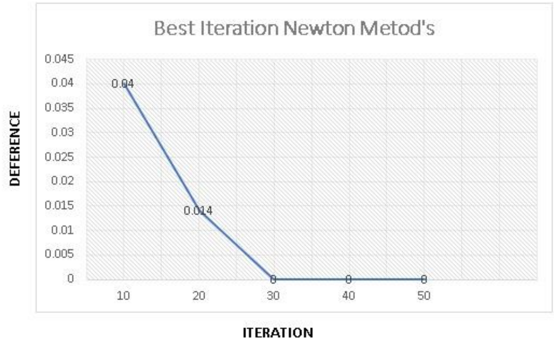

Figure 3. Chart of the best iteration testing

Figure 4. Chart of iteration testing using Newton's method

The next phase was testing Newton's method in the application of firefly algorithm in distance optimization.

In fitness testing some comparisons with other individual-based optical algorithms are evolution strategic (ES). with μ = number of feed combinations or called parent (2,3,4,5) and λ = 3 for each parent. Then compared with firefly algorithm which is not done distance optimization.

A number of input combination were conducted, and the results are as follows:

Tabel 5. Fitness result

Jumlah Kombinasi Pakan	Fitness		
	E.S	Firefly	Firefly + Newton
2	0,43085	1,03319	1,03321
3	0,35616	0,94230	1,03381
4	0,24605	1,03097	1,03154
5	0,23220	0,25330	0,48198

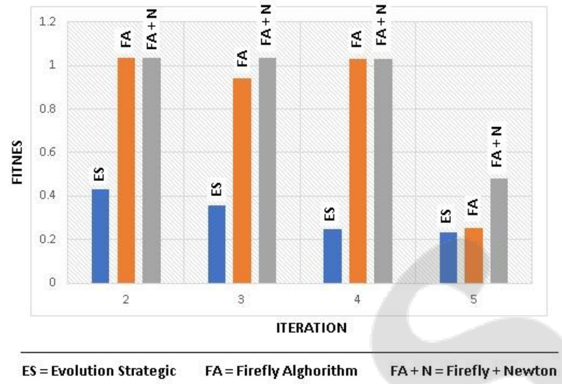

Figure 5. Chart of the comparison of fitness of firefly algorith, E.S (blue), FA (Red) and firefly algorithm optimized using Newton's method, FA + NW (metro)

The results of the testing of fitness between Evolution Strategic, normal firefly algorithm and firefly algorithm optimized using Newton's method showed an increase in the fitness. This shows that there was an increase in the light intensity which was influenced by distance, so the optimum result could be obtained.

7. Conclusion

For a series of test above, be obtained 20 the number of fireflies as the best solution for a total amount tertimggi Gym numbered 1 (scala 0-1). With the value of β (light intensity). With the movement kuang-kunangterbaik nilai γ = -0.2 dan α= -1.

From the test results on the algorithm of fireflies and then test methods newton on the number of iteration, iteration 30 best obtained by the difference amounted to 0.

Optimization was then performed at a distance (r) the firefly algorithm, generating kenaiikan fitness value. In the second combination of feed has increased by 0,002. In the third combined gain of 0.1 feed. At 4 combinations of feed rose 0,001 and the five combinations of feed increased by 0.2.

This shows the optimization method will increase the accuracy of calculations newon feed in determining optimal nutrition in chickens petelor.

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