

# Non-Linear Regression And Bisection Method Numerical Analysis of Humidity And Temperature Relationships

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**Abstract** - This study aims to analyze the correlation of temperature and humidity based on climatological data from Kuningan, West Java province, Indonesia, using non-linear regression and numerical analysis using the bisection method. In studying the education curriculum in Indonesia, most of them have studied linear regression, but only within certain limits, namely linear and multiple. It is still rare for students to use non-linear regression in their analysis. This paper will explain the analysis using non-linear regression as a source of data and equations in numerical analysis so that it can be applied in the context of the numerical bisection method. As for data processing and numerical analysis, Microsoft Excel is used. The authors combined the two variables in the non-linear analysis and used geometric equations for the numerical quotient analysis. The author displays the results of numerical graphs and real-time data obtained from the source "Data access viewer NASA."

**Keywords:** Non-Linear regresion; Bisection method; Numerical method.

## INTRODUCTION

Regression analysis is a fundamental method in many research problems because it involves analyzing the variables to be studied. In research, of course, there is not only one variable but many variables in the analysis (Codau et al., 2015). In many variables, of course, a method is needed how to be able to correlate these variables so that they have a relationship. Mathematical equations are the cornerstone in the analysis of these many variables. The analysis has at least two variables, X and Y.

The interpretation of non-linear relationships is fundamental in understanding statistical phenomena from physical data and understanding the world entirely in its analysis for several variables; regression analysis is needed, where its function involves many problems or phenomena in the scientific environment and non-scientific life.

The variables X and Y have a relationship, where these two variables can

be used as variables with a certain rank in the equation. Non-linear relationships are the basis for most physical and statistical phenomena, and their study is essential to understand the world around us fully. The least-square model in statistical data is an estimator in the non-linear regression of the parameters reviewed. Non-linear square serves to minimize the sum of squared errors (SSE).

In general, the regression analysis can be divided into 2, namely, Linear and non-linear regression (Amemiya, 1983). Many people think that distinguishing linear and non-linear regression only looks at the curvature of the line, but this is not entirely true, where the data model can adjust to the line equation. In non-linear regression, there are many forms, but in this article, we will explain the non-linear regression of the geometric type. (Pesaran & Deaton, 1978)

Variable analysis in this article is temperature and humidity. It has humidity in the air that contains water content (Crosdale

et al., 2008). The temperature at the location influences air humidity. In the correlation between humidity, it is directly proportional because the air with water content in it increases as the temperature increases (Roberts, 1960), so the location in the area under study will stretch due to the high temperature. The higher the temperature, the higher the humidity level at that location.

In this article, the numerical analysis uses the bisection method (Ayyub & McCuen, 1995). The bisection method is an approximation method to find the roots of the given equation by repeatedly dividing the interval (Jumin et al., 2021). We can find solutions to non-linear roots of equations using the bisection method (Zhao et al., 2014). We can run the numerical bisection process by using several processes or iterations and dividing the data by two. In the process, the principle of bisection is removing things that do not contain roots and taking things that contain roots, so you get the smallest.

**RESEARCH METHODS**

This study uses a numerical computational analysis method, where data

is taken from real data taken on the open access NASA web, namely from; <https://power.larc.nasa.gov/data-access-viewer/>. The data taken is a time series of temperature and humidity in the city of Kuningan, West Java province in 2021. In the analysis the data taken is 1 data per month, so you will get 12 temperature data and 12 humidity data. The variables are X and Y, where humidity is variable X, and temperature is variable Y.

In the regression analysis, the data for the x and y variables will be stretched to obtain the logarithmic values for the x and y variables, which aims to obtain the geometric equation (Brook & Arnold, 2018). After obtaining the parabolic equation, it can be taken to be analyzed using numerical analysis, namely analysis for 2, or commonly called the bisection method. The bisection method can function to find root values, and can find error or error values that you want to take in the analysis.

The data taken is as follows for variable x as humidity, and variable y as temperature, namely:

**Table 1.** Raw data of temperature and humidity

Month	Humidity (g/kg)	Temperatur (°C)
January	18,01	24,95
February	18,31	24,8
March	17,94	25,41
April	17,88	25,33
May	18,49	25,74
June	17,94	25,25
July	16,91	24,7
August	16,97	25,12
September	17,03	25,54
October	17,4	26,03
November	18,01	25,87
December	17,94	25,72
<b>Sum</b>	<b>212,83</b>	<b>304,46</b>

Source: <https://power.larc.nasa.gov/data-access-viewer/> (NASA)

This data is nonlinear data, so if we plot the scatter, we will get random and abstract or irregular results. So that it is necessary to process the data with the help of additional tables or commonly called regression analysis to obtain the geometric equations.

As for the geometric sales model, they are as follows:

$$\hat{Y} = aX^b \tag{1}$$

In the non-linear geometric equation above, there are constants a and b, which we can find. Before we look we have to log both sides of the equation, namely:

$$\log \hat{Y} = \log a + b \log X \tag{2}$$

So from this equation, we can get:

$$\hat{Y}' = a' + bX' \tag{3}$$

Or simply:

$$\log a = \frac{\sum \log y_i}{n} - b \left( \frac{\sum \log x^i}{n} \right) \tag{4}$$

And for b is:

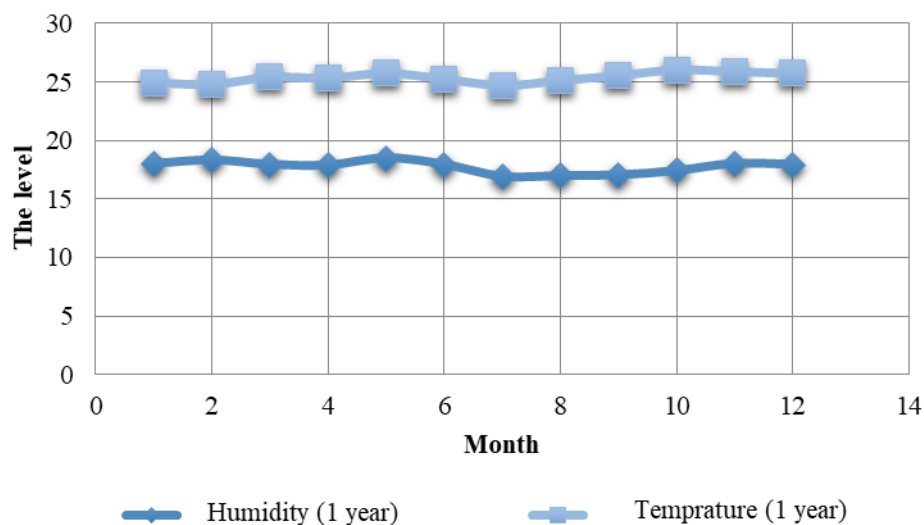
$$b = \frac{n(\sum \log y_i \cdot \log x_i) - (\sum \log x_i) \cdot (\sum \log y_i)}{n(\sum \log^2 x_i) - (\sum \log x_i)^2} \tag{5}$$

After we get the values of a and b, then we can substitute these values into equation (1), for numerical analysis using the bisection method.

The algorithm in the bisection method in this article is: **(a)** estimating the values of a and b, where for  $f(a) \cdot f(b) < 0$ , **(b)** then for the second step we can find the roots of the equation, using the c rule =  $(a+b)/2$ , if we get the value of c, then we can calculate  $f(c)$ . **(c)** evaluate using IF logic, where  $<f(a) \cdot f(c) < 0$ , then  $b=c$ , continue to the next step>,  $<f(a) \cdot f(c) > 0$ , then  $a=c$ , continue to the next step>,  $<f(a) \cdot f(c) = 0$ , stop iteration>.

## RESULTS AND DISCUSSION

The Figure 1 is the raw data correlation relationship between temperature and humidity, year 2021 in 12 months, in Kuningan City, West Java Province, Indonesia.



**Figure 1.** Time-dependent correlation of temperature and humidity raw data

Based on non-linear regression analysis using equations (1), (4), and (5) by describing additional data tables in the form

of logarithms, the result is that  $\log a = 1.280737032$ , so that a is 11.87407184, while for the constant value b is obtained

0.098949483. We can plot a and b into geometric equations as in equation (1), so we have obtained a geometric equation for the temperature and humidity correlations for the city of Kuningan in 2021, which is equal to the following equation.

$$Y = 11,87407184X^{0,0098949483} \quad (6)$$

Furthermore, if we have obtained the equation, then we may analyze the equation using the numerical bisection method First

of all we need to prepare the head table for inputting numeric data, which is like in the picture above. Next, input the value of a with 1, we enter b with 2 as the final limit in the analysis of the roots of the equation. For c is the middle value of a and b, in numeric excel it can be written as  $=(B26+C26)/2$ . We can input it into the function by substituting a, b, and c into equation (6), so we get:

**Table 2.** Scroll down after entering the logical if in the column

i	a	b	c	f(a)	f(b)	f(c)	error (ε)
1	1	2	0	11,87407184	12,71705163	12,36015199	0
2	1,5	2	1,75	12,36015199	12,71705163	12,55012818	0,142857

For machine programs in Exel to run as they should, then we can provide logic to Exel, namely evaluate using IF logic, where  $<f(a)*f(c)<0$ , then  $b=c$ , continue with the

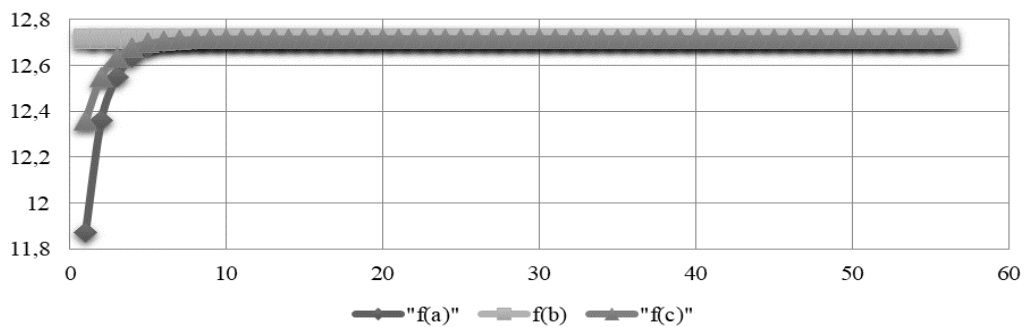
next step>,  $<f(a)*f(c)>0$ , then  $a=c$ , continue to the next step>,  $<f(a)*f(c)=0$ , stop iteration>. Next we may iterate until the iteration iteration for error is 0. as

**Table 3.** Numerical bisection method analysis

i	a	b	c	f(a)	f(b)	f(c)	error (ε)
1	1	2	0	11,87407184	12,71705163	12,36015199	0
2	1,5	2	1,75	12,36015199	12,71705163	12,55012818	0,142857
3	1,75	2	1,875	12,55012818	12,71705163	12,63609862	0,066667
4	1,875	2	1,9375	12,63609862	12,71705163	12,67716348	0,032258
5	1,9375	2	1,96875	12,67716348	12,71705163	12,69725019	0,015873
6	1,96875	2	1,984375	12,69725019	12,71705163	12,70718603	0,007874
7	1,984375	2	1,9921875	12,70718603	12,71705163	12,71212755	0,003922
8	1,9921875	2	1,99609375	12,71212755	12,71705163	12,71459176	0,001957
9	1,99609375	2	1,99804688	12,71459176	12,71705163	12,71582224	0,000978
10	1,99804688	2	1,99902344	12,71582224	12,71705163	12,71643707	0,000489
11	1,99902344	2	1,99951172	12,71643707	12,71705163	12,71674439	0,000244
12	1,99951172	2	1,99975586	12,71674439	12,71705163	12,71689802	0,000122
13	1,99975586	2	1,99987793	12,71689802	12,71705163	12,71697483	6,1E-05
14	1,99987793	2	1,99993896	12,71697483	12,71705163	12,71701323	3,05E-05
15	1,99993896	2	1,99996948	12,71701323	12,71705163	12,71703243	1,53E-05
16	1,99996948	2	1,99998474	12,71703243	12,71705163	12,71704203	7,63E-06
17	1,99998474	2	1,99999237	12,71704203	12,71705163	12,71704683	3,81E-06
18	1,99999237	2	1,99999619	12,71704683	12,71705163	12,71704923	1,91E-06
19	1,99999619	2	1,99999809	12,71704923	12,71705163	12,71705043	9,54E-07
20	1,99999809	2	1,99999905	12,71705043	12,71705163	12,71705103	4,77E-07
21	1,99999905	2	1,99999952	12,71705103	12,71705163	12,71705133	2,38E-07
22	1,99999952	2	1,99999976	12,71705133	12,71705163	12,71705148	1,19E-07

i	a	b	c	f(a)	f(b)	f(c)	eror ( $\epsilon$ )
23	1,99999976	2	1,99999988	12,71705148	12,71705163	12,71705156	5,96E-08
24	1,99999988	2	1,99999994	12,71705156	12,71705163	12,7170516	2,98E-08
25	1,99999994	2	1,99999997	12,7170516	12,71705163	12,71705161	1,49E-08
26	1,99999997	2	1,99999999	12,71705161	12,71705163	12,71705162	7,45E-09
27	1,99999999	2	1,99999999	12,71705162	12,71705163	12,71705163	3,73E-09
28	1,99999999	2	2	12,71705163	12,71705163	12,71705163	1,86E-09
29	2	2	2	12,71705163	12,71705163	12,71705163	9,31E-10
30	2	2	2	12,71705163	12,71705163	12,71705163	4,66E-10
31	2	2	2	12,71705163	12,71705163	12,71705163	2,33E-10
32	2	2	2	12,71705163	12,71705163	12,71705163	1,16E-10
33	2	2	2	12,71705163	12,71705163	12,71705163	5,82E-11
34	2	2	2	12,71705163	12,71705163	12,71705163	2,91E-11
35	2	2	2	12,71705163	12,71705163	12,71705163	1,46E-11
36	2	2	2	12,71705163	12,71705163	12,71705163	7,28E-12
37	2	2	2	12,71705163	12,71705163	12,71705163	3,64E-12
38	2	2	2	12,71705163	12,71705163	12,71705163	1,82E-12
39	2	2	2	12,71705163	12,71705163	12,71705163	9,09E-13
40	2	2	2	12,71705163	12,71705163	12,71705163	4,55E-13
41	2	2	2	12,71705163	12,71705163	12,71705163	2,27E-13
42	2	2	2	12,71705163	12,71705163	12,71705163	1,14E-13
43	2	2	2	12,71705163	12,71705163	12,71705163	5,68E-14
44	2	2	2	12,71705163	12,71705163	12,71705163	2,84E-14
45	2	2	2	12,71705163	12,71705163	12,71705163	1,42E-14
46	2	2	2	12,71705163	12,71705163	12,71705163	7,11E-15
47	2	2	2	12,71705163	12,71705163	12,71705163	3,55E-15
48	2	2	2	12,71705163	12,71705163	12,71705163	1,78E-15
49	2	2	2	12,71705163	12,71705163	12,71705163	8,88E-16
50	2	2	2	12,71705163	12,71705163	12,71705163	4,44E-16
51	2	2	2	12,71705163	12,71705163	12,71705163	2,22E-16
52	2	2	2	12,71705163	12,71705163	12,71705163	1,11E-16
53	2	2	2	12,71705163	12,71705163	12,71705163	1,11E-16
54	2	2	2	12,71705163	12,71705163	12,71705163	0

From the bisection numerical machine we can get the plot as follows:



**Figure 2.** Plots of functions against numbers (a,b, and c) in the geometric equations of temperature and humidity

And we can also see the error progress up to certain iterations, as seen below:

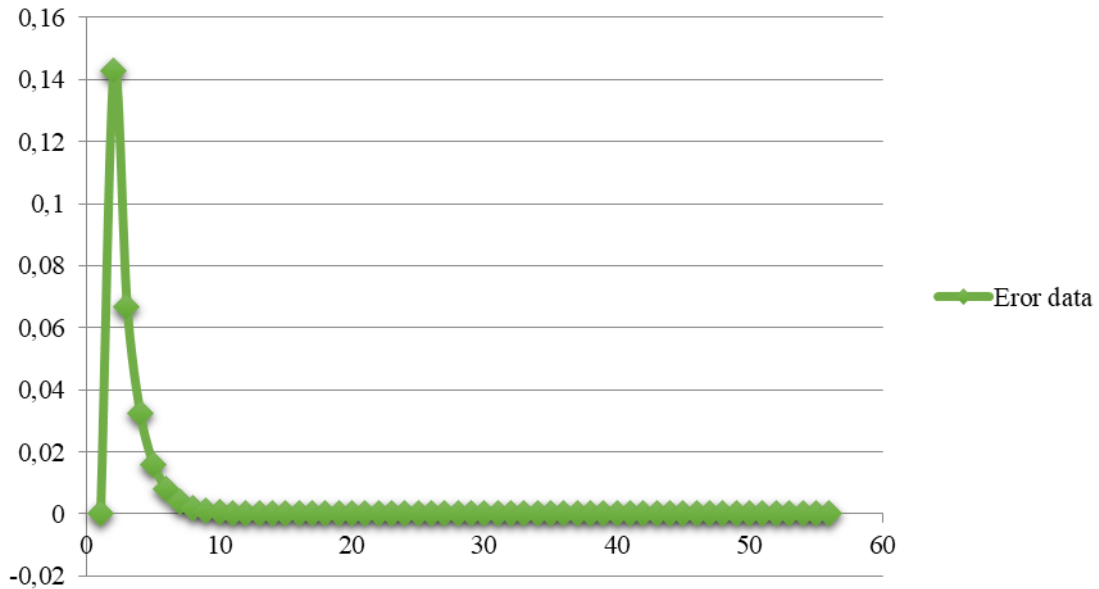


Figure 3. Error data analysis

**Discussion**

In this sub-chapter we will explain the graphs that we have attached above. For Figure 1 is a graph that interprets the relationship between temperature and humidity in the city of Kuningan, West Java, where in the graph we can see that the graph of temperature has a linear correlation with humidity so that we can do a correlation with regression, from these 2 variables it can be processed the data to be used as a non-linear equation. The non-linear graph that we use is a geometric type.

The next thing is if we have obtained data on variables x and y, which interpret humidity and temperature, then we can describe the data with logarithms, we must first get log a, log b, multiply log a and log b, square log a and square log b, and the amount of data, while the amount of data taken is 12 because it interprets 12 months in 1 year. After we get the log data, then we add up each data, for further processing.

We get the value b, which is 0.098949483, from equation 5, we get the log a value from equation 4, where we process the log a to a value of a, which is 11.87407184 using the power rule, so the log

is lost. So that's where we get the values of a and b, to be entered into the geometric equation variables.

If we study the equations, of course we can process these equations into the bisection numerical method. The bisection method is a closed method for finding solutions to the roots of non-linear equations. In table 2 is the head table which we will process in the bisection numerical method. For machine programs in Exel to run as they should, then we can provide logic to Exel, namely evaluate using IF logic, where  $\langle f(a)*f(c) < 0, \text{ then } b=c, \text{ continue with the next step} \rangle$ ,  $\langle f(a)*f(c) > 0, \text{ then } a=c, \text{ continue to the next step} \rangle$ ,  $\langle f(a)*f(c) = 0, \text{ stop iteration} \rangle$ .

Next we may iterate until the iteration iteration for error is 0. After we do logic on the data, we can drag it so we get the value we want as shown in table 4. Figure 1 is an interpretation in table 4 which states the roots of the equation, from f(a) to f(b). For f(b) we take the numeric value is 2, and f(a) we take the numeric is 1, but the numeric does not have to have that value, we can also take the constraints randomly, depending on what we need in the method. Of course f(b)

will remain constant, while  $f(a)$  will approach  $f(b)$ , so  $f(a)$  will be equal in value to  $f(b)$ . Whereas  $f(c)$  is the middle value between  $f(a)$  and  $f(b)$ , from this,  $f(c)$  will always be in the middle value between  $f(a)$  and  $f(b)$ . Figure 3 is an error graph of  $f(a)$  and  $f(b)$ , where the maximum data error is 0.15 from 0, and will decrease again per iteration or 50 repetitions.

## CONCLUSION

As for this paper, it has succeeded in explaining the bisection method for 2 nonlinear data using geometric equations. The data obtained uses real data for 2021 for the city of Kuningan, so that students can use this data to practice linear regression analysis and other numerical methods. In this paper, we explain non-linear regression teaching strategies and their relationship with the numerical bisection method with 2 different variables. This strategy is also expected to help lecturers and other researchers. It is suggested to the readers to develop 4 different numerical methods using the same data, and using real data from open access. It is also hoped that students or students will not only read theory, but can practice in other programming languages, such as Matlab, Python and so on.

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