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K-Nearest Neighbor Algorithm for Predicting Land Sales Price

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ABSTRACT

Until now, there are still many people who have difficulty making choices in choosing strategic land at a price according to their abilities due to lack of knowledge about land prices based on market prices. Based on these problems, the design and manufacture of applications that can be used to predict the selling price of land with the K-Nearest Neighbor (KNN) algorithm approach. This application is expected to provide more accurate and efficient information about the selling price of land and help prospective buyers or sellers of land to predict the value of land according to the specified criteria. The data collected is secondary data. The method used is a combination of data mining stages known as the Cross-Industry Standard Process for Data Mining (CRISP-DM) and the Waterfall Model software development method. Overall, this application is able to predict land value with a fairly long processing because the KNN algorithm is basically comparing testing data (new data) with training data (old data) one by one. The accuracy of the testing data prediction is 80%.
Keyword : Prediction, Land Price, K-Nearest Neighbor

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1. INTRODUCTION

Increasing population growth has resulted in higher demand for land. Of course, it is not only the growth rate or population level that must be taken into account, but the existence of funds owned by the community is also very influential. In addition, the economic growth of a country also affects the movement of land prices. If the available land cannot meet all the demand, the next result is an increase in land prices. This is what causes the trend of land prices to increase from year to year.

The forces of supply and demand interact to influence the value of land, which is reflected in the sales price. In the short term, supply becomes very inelastic, as land area cannot be increased quickly and drastically. Meanwhile, the need for land as a place to live or a place of business or as an investment item is getting closer to the symptoms of durable consumption goods.

Basically, the price of land is determined by two factors, namely tangible factors such as strategic land location, close to the city center and intangible factors. Unmeasurable factors are mostly caused by socio-psychological aspects that are difficult to study scientifically, such as comfort and safety. Until now, there are still many people who find it difficult to make choices in choosing strategic land at a price according to their abilities due to lack of knowledge about land prices based on market prices.

The problem to be solved in this research is how to predict the selling price of land based on measurable factors. To solve it, experiments will be conducted based on measurable data such as the distance of the location to the city center, schools, hospitals and so on. The approach used to predict the selling price of land is the K-Nearest Neighbor (KNN) algorithm.

2. RESEARCH METHOD/MATERIAL AND METHOD/LETERATURE REVIEW

Related to the problem to be solved, the literature review that is important to understand is the theory of determining the selling price of land and the K-Nearest Neighbor method.

A. Land Value

Land is one of the factors of production that cannot be produced by humans. Good land utilization will ensure the continuity of a stable ecosystem, limit air pollution, and can create a political, economic, social, cultural, defense, and national security structure of society [7].

Ray M. Northam (1975), see [4], suggests two notions of land value, namely:

1. Land value is the market value, which is the price at which land is bought and sold at a certain time.
2. Land value is assessed value, which is the value estimated by an appraiser. Market value is the basic data for assessed value.

According to Shenkel, as cited by [8], land value has various definitions or meanings depending on the context and purpose as well as the point of view.

Land value is by definition the strength of the value of land in exchange for other goods. For example, land with low productivity, such as pasture land, has a relatively lower value due to its limited use. Meanwhile, the market value of land is defined as the price (measured in units of money) that sellers and buyers want to pay.

Land value in the context of the property market is fair market value, namely the value determined or determined by buyers who want to buy something and sellers want to sell something based on the agreement or agreement of both parties in reasonable conditions without any pressure from outside parties in the sale and purchase transaction process so that there is agreement. Buyers and sellers have sufficient time for the property being traded and act in their own interests.

According to Peace and Turner cited by [8], non-human factors relate to the externalities received by the land. If the externality is positive, such as close to the economic center, free of flooding, population density, and the presence of road facilities, then the land will have a high value when compared to land that does not receive externalities, even though the area and shape of the land are the same. If the land receives negative externalities, such as close to garbage, far from the city/economic center, not free of flooding, then the land will have a low value compared to land that does not receive negative externalities [5].

To conduct a land valuation, it is necessary to know some valuation principles. According to Joseph K. Eckert, as cited by [8], put forward four principles of land valuation, namely supply and demand, the highest and the best use, surplus productivity, and the principle of change and anticipation.

B. Factors Affecting Land Value

In the journal of the American Institute of Real Estate Appraisers [10], there are four factors that affect land value, namely

1. Economic Factors
   Economic factors relate to global/international, national, regional and local economic conditions. Demand variables that affect land values include the amount of labor, wage levels, income levels and purchasing power, availability of finance, interest rates and transaction costs.
2. Social Factors
   Social factors shape land use patterns in an area. Population density, education level, crime rate and pride of ownership (prestigious areas) are social factors that influence land values.
3. Political Factors and Government Policies
   Government policies in the legal and political spheres affect land values. Some examples of policies that can affect the cost and allocation of land use, which in turn will increase land prices, include: land certificate ownership policies, spatial planning regulations with zoning, tax regulations, licensing regulations (SIPPT, IMB, etc.) or determination of public service locations (primary schools, hospitals, etc.).
4. Physical and Environmental Factors

There are two concepts that must be understood in physical and environmental factors, namely site and situation. The definition of site is all the internal properties or characters of the site. A certain parcel or area, including size, shape, topography and all physical conditions on the land parcel. While what is meant by the situation (situation) is related to its external properties. The situation of a place is closely related to the relationship of that place with the surrounding places in the same geographic space.

Included in the understanding of the situation is accessibility (distance to the shopping center (CBD), distance to schools distance to hospitals, etc.), the availability of facilities and infrastructure (city utilities) such as transportation networks, telephone lines, electricity, drinking water and so on. Site affects land value because of its "resources", while situation affects land value because of its convenience or proximity (accessibility) to other "resources" around it.

According to Abd. Rahman M. Noor, as cited by [8] in the journal Development Economics, Appraisal is an assessment and opinion on the value of a property / wealth by an appraiser based on the interpretation of factors and beliefs at a certain time or date. Meanwhile, according to Wolcott as cited by [8], suggests that the concept of value is generated due to the following economic factors:

a. Utility, which is the ability of an object to satisfy human wants, needs and tastes, for example, land on which houses can be built for human habitation. The utility of a property depends on its characteristics, such as size (land or building area), building design, accessibility, location, ownership rights and other forms of utility that affect the value of the property.
b. Scarcity, which is a good that is available in limited quantities will make the object valuable or it can also be said that the availability or supply of a commodity is relative to its demand.
c. Desire/demand, that the demand for an object shows that the object is valuable or the buyer's expectation of a commodity to be able to satisfy his life needs or individual desires.
d. Effective purchasing power, is the ability of an individual or group to participate in the market in acquiring a commodity, in exchange for a certain amount of money or other goods equivalent to it.

According to Eldred, as cited by [8] in the journal Development Economics, the factors that determine the economic value of a land property are:

a. Demand that shows a person's desire and ability to buy or rent a property.
b. Usability that shows the benefits of the subject property that can provide satisfaction to consumers.
c. Scarcity indicates the quantity and quality of other properties that compete with the subject property in question.
d. Transferability refers to the process of transferring property rights from one party to another through sale, purchase, lease and contract.

C. K-Nearest Neighbor Algorithm

The K-Nearest Neighbor (KNN) algorithm is a method for classifying objects based on learning data that is closest to the object. The learning data is projected onto a multi-dimensional space, where each dimension represents a feature of the data. This space is divided into parts based on the classification of the learning data. A point in this space is assigned class c if class c is the most common classification among the k nearest neighbors of the point. Near or far neighbors are usually calculated based on the Euclidean distance with the formula in equation (1),

with

X itraining : i-th training data,
Xtesting : testing data,
i : the i-th record (row) of the table,
n : number of training data.

In the learning phase, the algorithm only performs feature vectors storage and classification of the learning data. In the classification phase, the same features are calculated for the test data (whose classification is unknown). The distance of this new vector to all the learning data vectors is calculated, and the K closest ones are taken. The newly classified point is predicted to belong to the classification of the most of these points. The best value of K for this algorithm depends on the data. In general, a high K value will reduce the effect of noise on classification, but make the boundaries between each classification more blurred. A good K value can be chosen by parameter optimization, for example by using cross-validation. The special case where the classification is predicted based on the closest learning data (i.e., K = 1) is called the nearest neighbor algorithm.

The accuracy of the KNN algorithm is greatly influenced by the presence or absence of irrelevant features, or if the weight of the feature is not equivalent to its relevance to the classification.

The KNN algorithm has several advantages, namely resilience to training data that has a lot of noise and is effective when the training data is large. Meanwhile, the disadvantages of KNN are that KNN needs to determine the value of the K parameter (number of nearest neighbors), training based on distance is not clear about what type of distance should be used and which attributes should be used to get the best results, and computational costs are quite high because it requires calculating the distance of each query instance on the entire training sample.

K-Nearest Neighbor (KNN) is a method that uses a supervised algorithm where the results of new query instances are classified based on the majority of categories in KNN. The goal of this algorithm is to classify new objects based on attributes and training samples. The classifier does not use any model to match and is based solely on memory. Given a query point, it will find a number of K objects or (training points) that are closest to the query point. Classification uses the most votes among the classifications of the K objects. The KNN algorithm uses the neighboring classification as the predicted value of the new query instance.

As an illustration of the application of the KNN algorithm is for example there is data from a survey with a questionnaire, to ask people's opinions on a test with two attributes (acid resistance and strength), to classify whether a tissue paper is of good quality or not [9]. The following are four training samples (training data).

Explaining research chronological, including research design, research procedure (in the form of algorithms, Pseudocode or other), how to test and data acquisition [1-3]. The description of the course of research should be supported references, so the explanation can be accepted scientifically [2, 4]. Tables and Figures are presented center, as shown in Table 1 and Figure 1, and cited in the manuscript and should appeared before it.

Table 1. Training Data Table

X_1 = Acid Durability (seconds)	X_2 = Strength(kg/sqm)	Classification
7	7	Bad
7	4	Bad
3	4	Good
1	4	Good

As a case in point, let's say that a paper mill has produced a new tissue that passed the laboratory test with X1 =3 and X2 =7. To guess the classification of this new tissue, calculations are carried out using the KNN algorithm.

The steps to calculate K nearest neighbors with the KNN algorithm are as follows.

a. Determine the parameter K (number of nearest neighbors). Suppose K = 3
b. Calculate the distance between the query (testing data) and all training examples (training data). The training data to calculate the proximity has coordinates (3,7).

Table 2: Distance Calculation Table

X_1 = Acid Durability (seconds)	X_2 = Strength (Kg/sqm)	Square Distance to sample demand (3, 7)
7	7	$(7\text{-}3)^2 + (7\text{-}7)^2 = 16$
7	4	$(7\text{-}3)^2 + (4\text{-}7)^2 = 25$
3	4	$(3\text{-}3)^2 + (4\text{-}7)^2 = 9$
1	4	$(1\text{-}3)^2 + (4\text{-}7)^2 = 13$

c. Sort the distances and determine the nearest neighbor based on the Kth closest distance.

Table 3. Minimum Distance Rank Order

X_1 = Acid Durability (seconds)	X_2 = Strength (Kg/sqm)	Square Distance to demand instance (3, 7)	Minimum distance rating	Is included in-nearest neighbor 3?
7	7	$(7\text{-}3)^2 + (7\text{-}7)^2 = 16$	3	Yes
7	4	$(7\text{-}3)^2 + (4\text{-}7)^2 = 25$	4	No
3	4	$(3\text{-}3)^2 + (4\text{-}7)^2 = 9$	1	Yes
1	4	$(1\text{-}3)^2 + (4\text{-}7)^2 = 13$	2	Yes

d. Collect the Y category from the nearest neighbor row. In the second row, the nearest neighbor category (Y) is not included because the data ranks more than 3 nearest neighbors.
e. Use majority simple from the neighbor category nearest as predicted value example query.

From the table above, two new tissue papers of good quality and one new tissue paper of poor quality are obtained. Because the nearest neighbors obtained are more of good quality, it can be concluded that the new tissue paper that passed the laboratory test with X1 =3 and X2 =7 is in the good category.

The method used is using engineering methods with a waterfall model approach which includes analysis, design, implementation and testing stages combined with data mining methods known as Cross-Industry Standard Process for Data Mining (CRISP-DM). At the analysis stage, a preliminary survey was conducted regarding data that was thought to affect the selling price of land. The data collected is in the form of secondary data, namely in the form of road width, distance to shops, road conditions, population density, flood-free, public transportation, telephone network, PDAM channels, school distance, hospital distance, electricity lines, property rights, land size, supply demand, existing buildings, cardinal directions, and land value (land selling price). The variables above are then used as a reference for data collection.

After analyzing the system, the next step is to design the process, input, output, database, graphical user interface (GUI), and program that will be made to make predictions. In general, the process design of the application is shown in Figure 1.

Figure 1. Context Diagram

The application procedure for the above diagram is given in Figure 2 below.

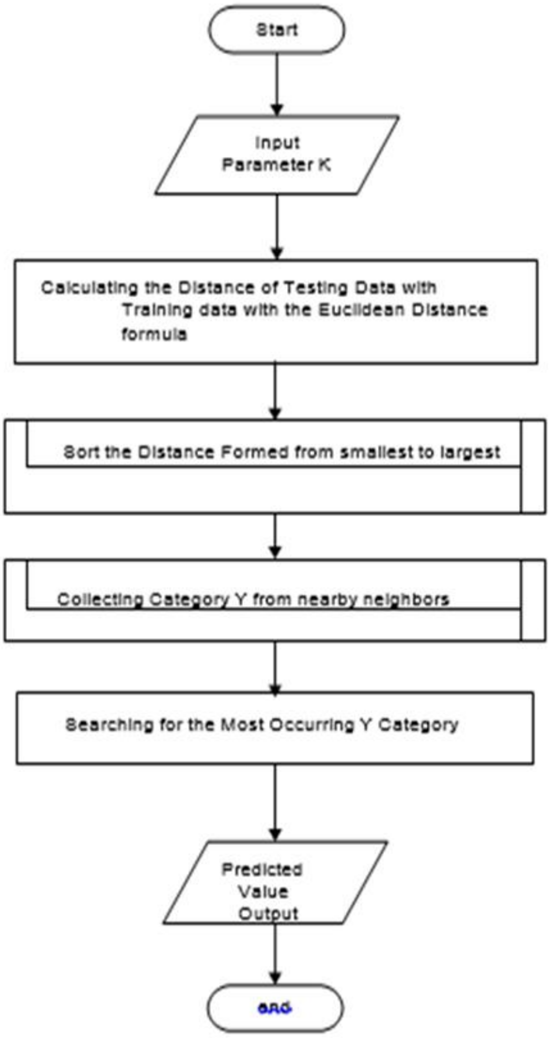


Figure 2. Application Procedure with KNN

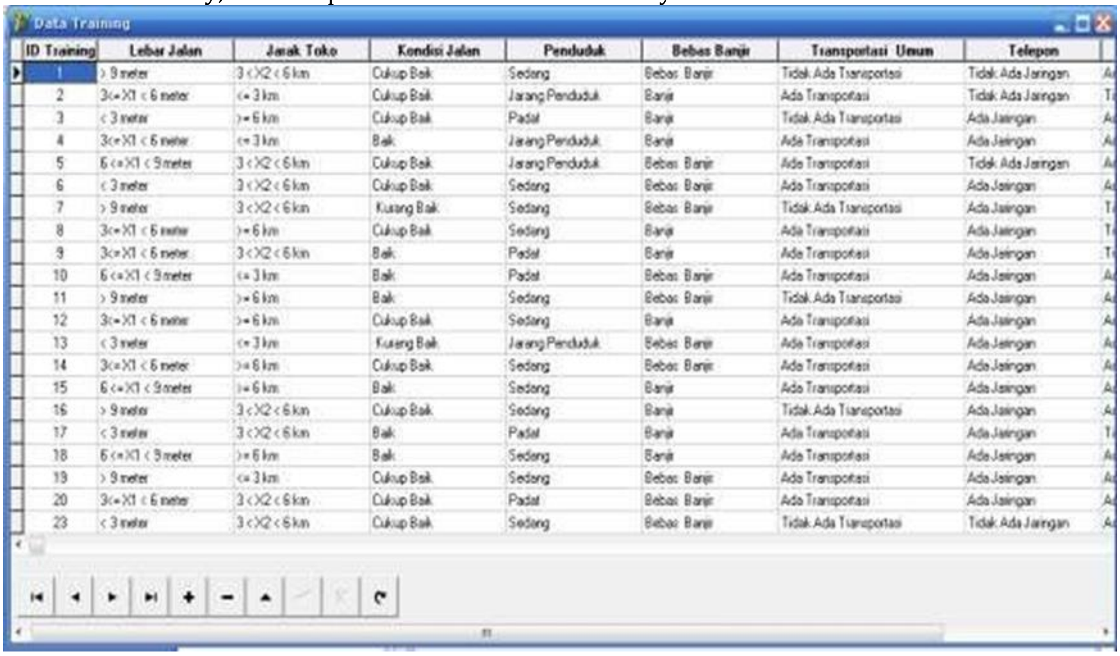
3. RESULTS AND DISCUSSION

This section will discuss the results of the implementation and discussion of the test results of the application program. The application is made with a menu structure as in Figure 3.

Figure 3. Application Menu Structure

The process on training data and testing data is the core of the discussion of the application made. Training data is used to store old cases that have known land values, so that when new data is entered (called testing data), the land value can be predicted based on proximity measures. As an example of training data.

The training data shows the value of each attribute associated with a soil data at a particular location. In this study, 100 samples of soil data in the Surabaya area were taken.

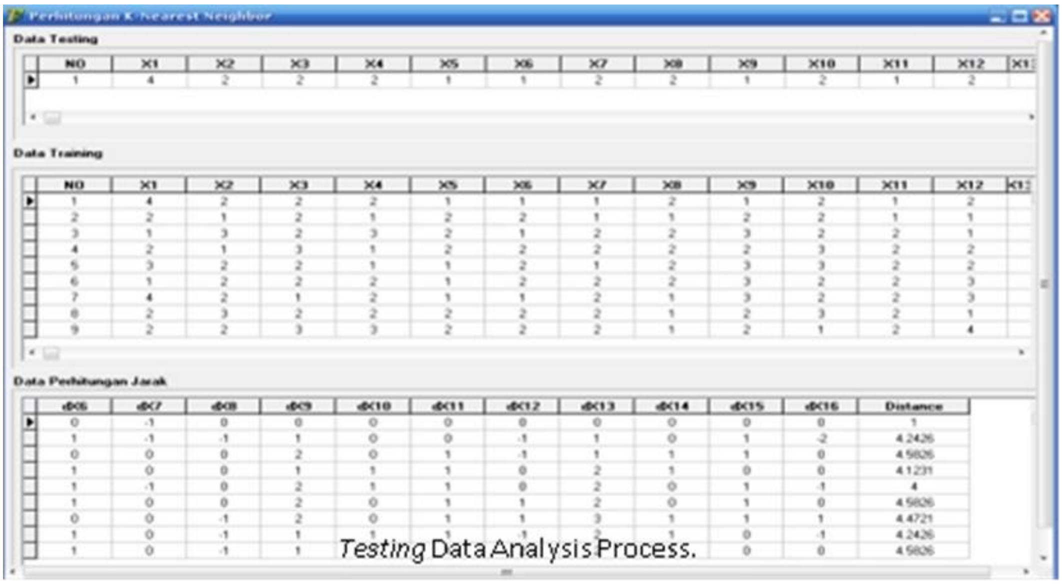


Data Training

ID Training	Lebar Jalan	Jarak Toko	Kondisi Jalan	Penduduk	Bebas Banjir	Transportasi Umum	Telepon	
1	> 9 meter	3 < X2 < 6 km	Cukup Baik	Sedang	Bebas Banjir	Tidak Ada Transportasi	Tidak Ada Jaringan	A
2	3<=X1 < 6 meter	<= 3 km	Cukup Baik	Jarang Penduduk	Banjir	Ada Transportasi	Tidak Ada Jaringan	T
3	< 3 meter	>= 6 km	Cukup Baik	Padat	Banjir	Tidak Ada Transportasi	Ada Jaringan	A
4	3<=X1 < 6 meter	<= 3 km	Baik	Jarang Penduduk	Banjir	Ada Transportasi	Ada Jaringan	A
5	6 <=X1 < 9 meter	3 < X2 < 6 km	Cukup Baik	Jarang Penduduk	Bebas Banjir	Ada Transportasi	Tidak Ada Jaringan	A
6	< 3 meter	3 < X2 < 6 km	Cukup Baik	Sedang	Bebas Banjir	Ada Transportasi	Ada Jaringan	A
7	> 9 meter	3 < X2 < 6 km	Kurang Baik	Sedang	Bebas Banjir	Tidak Ada Transportasi	Ada Jaringan	T
8	3<=X1 < 6 meter	>= 6 km	Cukup Baik	Sedang	Banjir	Ada Transportasi	Ada Jaringan	T
9	3<=X1 < 6 meter	3 < X2 < 6 km	Baik	Padat	Banjir	Ada Transportasi	Ada Jaringan	T
10	6 <=X1 < 9 meter	<= 3 km	Baik	Padat	Bebas Banjir	Ada Transportasi	Ada Jaringan	A
11	> 9 meter	>= 6 km	Baik	Sedang	Bebas Banjir	Tidak Ada Transportasi	Ada Jaringan	A
12	3<=X1 < 6 meter	>= 6 km	Cukup Baik	Sedang	Banjir	Ada Transportasi	Ada Jaringan	A
13	< 3 meter	<= 3 km	Kurang Baik	Jarang Penduduk	Bebas Banjir	Ada Transportasi	Ada Jaringan	A
14	3<=X1 < 6 meter	>= 6 km	Cukup Baik	Sedang	Bebas Banjir	Ada Transportasi	Ada Jaringan	A
15	6 <=X1 < 9 meter	>= 6 km	Baik	Sedang	Banjir	Ada Transportasi	Ada Jaringan	A
16	> 9 meter	3 < X2 < 6 km	Cukup Baik	Sedang	Banjir	Tidak Ada Transportasi	Ada Jaringan	A
17	< 3 meter	3 < X2 < 6 km	Baik	Padat	Banjir	Ada Transportasi	Ada Jaringan	T
18	6 <=X1 < 9 meter	>= 6 km	Baik	Sedang	Banjir	Ada Transportasi	Ada Jaringan	A
19	> 9 meter	<= 3 km	Cukup Baik	Sedang	Bebas Banjir	Ada Transportasi	Ada Jaringan	A
20	3<=X1 < 6 meter	3 < X2 < 6 km	Cukup Baik	Padat	Bebas Banjir	Ada Transportasi	Ada Jaringan	A
23	< 3 meter	3 < X2 < 6 km	Cukup Baik	Sedang	Bebas Banjir	Tidak Ada Transportasi	Tidak Ada Jaringan	A

Figure 4. Sample Training Data

To test the testing data, input testing data and enter the number of closest data (K) considered. The output of the data distance calculation results comparing the attribute values in the testing data with the attribute values in all training data will be displayed in the dialog on the left.



Perhitungan K-Nearest Neighbor

Data Testing

NO	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X1
1	4	2	2	2	1	1	2	2	1	2	1	2	

Data Training

NO	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X1
1	4	2	2	2	1	1	1	2	1	2	1	2	
2	2	1	2	1	2	2	1	1	2	2	1	1	
3	1	3	2	3	2	1	2	2	3	2	2	1	
4	2	1	3	1	2	2	2	2	2	3	2	2	
5	3	2	2	1	1	2	1	2	3	3	2	2	
6	1	2	2	2	1	2	2	2	3	2	2	3	
7	4	2	1	2	1	1	2	1	3	2	2	3	
8	2	3	2	2	2	2	2	1	2	3	2	1	
9	2	2	3	3	2	2	2	1	2	1	2	4	

Data Perhitungan Jarak

dX6	dX7	dX8	dX9	dX10	dX11	dX12	dX13	dX14	dX15	dX16	Distance
0	-1	0	0	0	0	0	0	0	0	0	1
1	-1	-1	1	0	0	-1	1	0	1	-2	4.2426
0	0	0	2	0	1	-1	1	1	1	0	4.5826
1	0	0	1	1	1	0	2	1	0	0	4.1231
1	-1	0	2	1	1	0	2	0	1	-1	4
1	0	0	2	0	1	1	2	0	1	0	4.5826
0	0	-1	2	0	1	1	3	1	1	1	4.4721
1	0	-1	1	1	1	-1	2	1	0	-1	4.2426
1	0	-1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	4.5826

Testing Data Analysis Process.

Figure 5. Testing Data Analysis Proses

To see more details of the calculation of training data and testing data and their distances, can be seen in the Details menu. Next, a form will appear that displays all the data needed in calculating the proximity distance between new data and old data. An example of the results of distance calculations from testing data and training data can be seen in Figure 6.

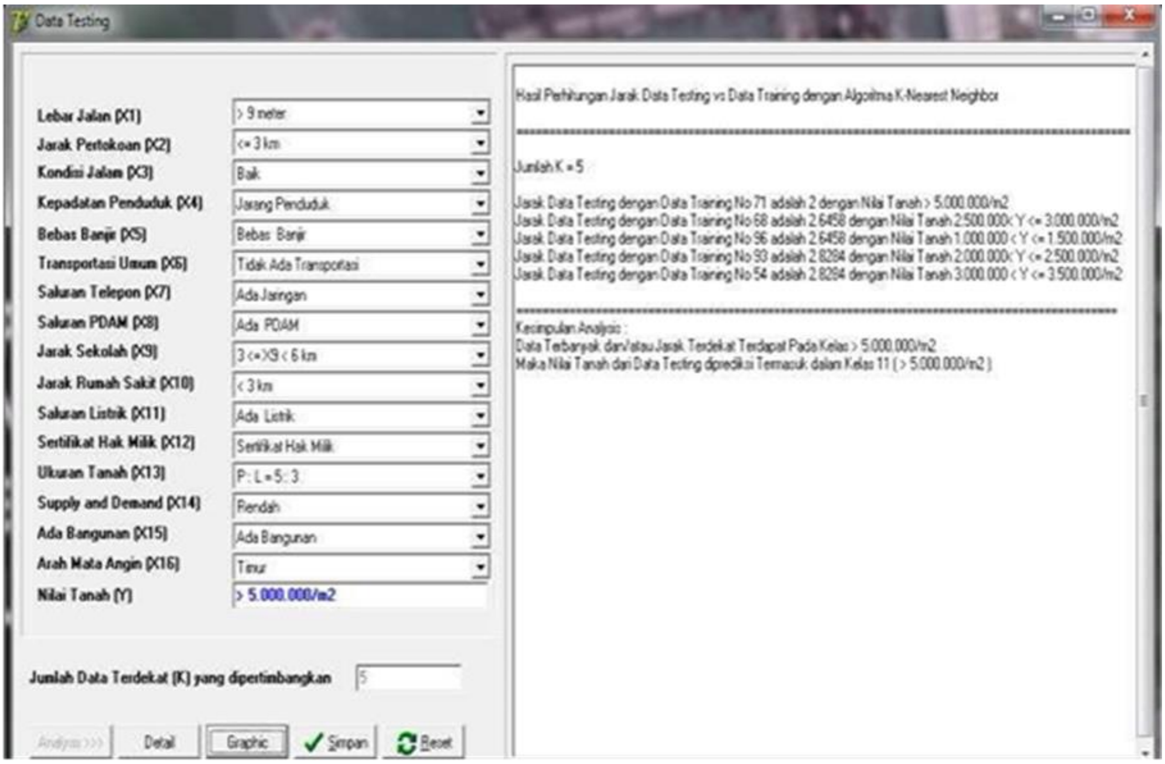


Figure 6. Testing and Training Data Distance Calculation Result Data

Meanwhile, to see the comparison graph of testing data with training data, the facility is given to see the graph. An example of this comparison can be seen in Figure 7.

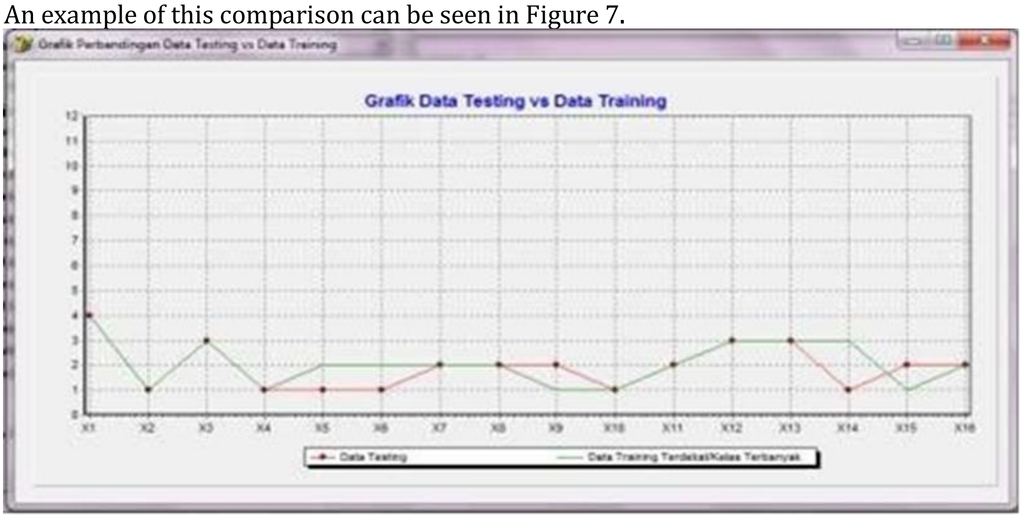


Figure 7. Comparison chart of Testing Data with Training

After the application is ready to use, an evaluation is carried out to measure the level of precision of the predicted land value in the Surabaya area. The evaluation can be seen in the table below.

Table 4. Table of Precision Level of Land Value Prediction in Surabaya Region.

No	Region	Actual		
1.	Gayungan, A. Yani	10.000.000/m^2	> 5.000.000/m^2	Correct
2.	Nginden, Semolo	4.350.000/m^2	> 5.000.000/m^2	Wrong
3.	Jl. Kedungdoro	6.200.000/m^2	> 5.000.000/m^2	Correct
4.	Prapen / Jemursari	6.500.000/m^2	> 5.000.000/m^2	Correct
5.	Embong Wungu Street	8.000.000/m^2	> 5.000.000/m^2	Correct
6.	Ear Gorge,	530.000/m^2	500,000<Y=<1jt/m^2	Correct
7.	Pakis Street	1.960.000/m^2	1.5 jt<Y<=2 jt/m^2	Correct
8.	Keputih, Sukolilo	1.500.000/m^2	1.5 jt<Y<=2 jt/m^2	Wrong
9.	Tenggilis, Mejoyo	1.600.000/m^2	1.5 jt<Y<=2 jt/m^2	Correct
10.	Wonorejo Asri	485.000/m^2	400.000<Y<=500.000	Correct

Based on the data prediction results above, the accuracy level of this prediction can be said to be 80%. This accuracy rate can be improved by increasing the amount of training data, so that new cases that will be predicted have reference values in the database.

4. CONCLUSION

Based on this research, it is obtained that the resulting application has a fairly long processing rate because the testing data (new data) is compared one by one with the training data (old data). This is because the number of attributes used to predict land value is quite a lot, namely 16 variables which include road width, road conditions, flood conditions, distance between land and shops, schools and hospitals, telephone lines, PDAM, electricity and many others. The precision level of the resulting prediction is around 80%. To improve the accuracy, more sample data is needed for the training process. In addition, further research can also be done to predict with other algorithms such as regression analysis, decision tree and so on.

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