Statistical lCharacteristics For Identification Defect of Solar Panel with Naive Bayes

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Abstract. Energy that comes from the sun is energy without limits and never runs out. This energy is alternative energy that can be converted into electrical energy, namely by using solar cells. But people who live in remote areas will have difficulty getting electricity. Solar panels are an alternative power source. Solar panels are an alternative way to produce electricity. The production of good solar panels is an important thing that must be done to produce the desired electrical energy. The uncontrolled production process causes various types of defects that appear in solar panels. This study applies the Bayes theorem to classify data by estimating the probability that tuple X is in a class. Using thirty samples consisting of fifteen images of undamaged solar panels and fifteen images. The level of accuracy of image processing for identification of flawed solar panel textures by the Naive Bayesian Classifier method or Simple Bayesian Classifier is around eighty three percent. The results of this study are expected to be used as a reference for the initial detection system of damage that occurs on the surface of the Solar Panel

Keywords: *Energy, image processing, a defect of solar panel, Bayesian Classifier.*

1. Introduction

Indonesia is one of the tropical countries and has uniform sunlight and can be captured throughout the Indonesia archipelago throughout the year. Therefore the sun is a potential energy source [1]. Energy is obtained from heat that propagates to the surface of the earth. The choice of renewable energy sources makes perfect sense because solar energy obtained from sunlight can reach 3x1024 Joules per year[2]. To get and process energy in the sun so that it can be used to fulfill daily needs, the Solar Panel is used. In the use of solar panels, of course there is care that must be done. Solar panels must be in good condition in order to produce the appropriate energy expected. damage that occurs after use arises on the surface of the solar panel. It is difficult to identify or detect some defects or damage properly because it could have happened in a hidden manner in the system so that it is difficult to identify until in the end the entire system is destroyed [3]. Recycling solar panels that are not used can cause environmental damage if not handled carefully because the materials used are silicon, selenium, cadmium, and sulfur hexafluoride (greenhouse gas) [4]. this will become a new problem in the environmental recycling process [5].

Fatalities can occur due to slow detection of damage. Several severe fire hazards have been reported due to late reporting of damage [6], the 2009 fire incident at California Bakersfield and also in 2011, there was a fire at a 1 MW PV power plant in Mount Holly Northern California. Several studies have been carried out with other methods using images of solar panels as data material [7]. Other research uses methods to detect cracks of solar panels by image processing, which contain gray transformations, contour detection, with Gauss-Laplacian transformation [8]. This study applies the Bayes theorem to classify data and make estimates to determine the probability that a tuple X is in a class. The method used is Naive Bayesian Classifier or Simple Bayesian Classifier. By using images surface photos that will be used as data sets to distinguish which images of damaged Solar Panels and Solar Panels are not damaged. The results of this study are expected to be used as a reference for the initial detection system of damage that occurs on the surface of the Solar Panel

2. Method

This study applies the Bayes theorem to classify data by estimating the probability that tuple X is in a class. Using thirty samples consisting of fifteen images of undamaged solar panels and fifteen images. The method used is Naive Bayesian Classifier or Simple Bayesian Classifier. The calculation technique used is Laplacian Correction or Laplace Estimator to avoid a probability of zero value.

2.1 Texture of Image

The texture is the spatial distribution of grayscale in the groups of pixels. Texture of image cannot identify for pixels. The surface have texture information; if the area enlarged without a scale, they have similar properties to the original surface[9]. Regular patterns appear with a certain distance and direction. The noncolored surface in the image can contain texture information if the surface has a certainpattern such as used wood surface, stone surface, sand beds, etc.

Texture analysis is commonly used as an intermediate process[10]. For performing image classification and interpretation, An image classification process based on texture analysis generally requires feature extraction which can consist of two types of methods: statistical methods and structural methods. Statistical methods use the calculation of the gray level disribution[11]. Statistic method use the calculation of the gray level distribution statistics by measuring the level of contrast and granularity[12]

2.2 Statistic Feature Extraction

The feature extraction method is retrieval based on the characteristics of the image histogram, that shows the probability of the occurrence of the value of the greyscale in an image[13]. The result of the histogram, several parameters can be calculated, including mean, variance, skewness, kurtosis and entropy.

The calculation curve of the characteristic parameters for the surface texture of the solar panel shown in figure 1 and 2.

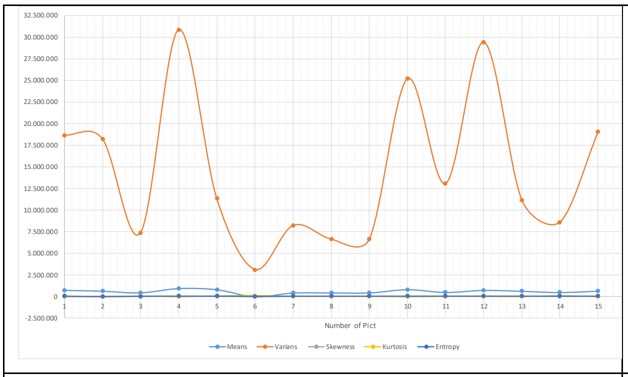

Figure 1. Characteristic Curve of Normal Solar Panel

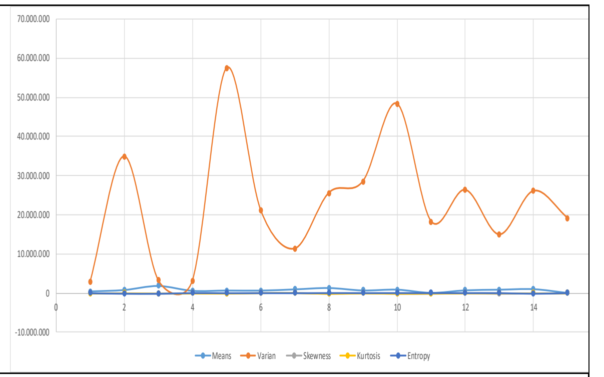

Figure 2. Characteristic Curve of Defect Solar Panel

3. Findings and Discussion

This study will test 30 images with a *.jpg extension. From 30 image data, the value of the texture parameters will be determined namely mean, variance, skewness, kurtosis,and entropy. Where 15 sampleshavebeen taken on normal and abnormal solar panel surface texture. The solar panel image in jpg format is converted to grayscale and displayed on the grayscale histogram.

3.1. *Means*

Shown the size of dispersion of image.

$$\mu = \sum_{n=0}^{N} f_n . P(f_n) \qquad (1)$$

Where,

Fn = Gray inteensity

P(fn) = Histogram Value

3.2. *Variance*

Shown variation elements on the histogram

$$\delta^2 = \sum_{n=0}^{N} (f_n - \mu)^2 P(f_n) \qquad (2)$$

Where,

Fn = Gray intensity

µ = Means

P(fn) = Histogram Value

3.3. Skewness

Show the degree of inclination of the relative histogram curve of an image

$$\alpha_3 = \frac{1}{\delta^3} \sum_{n=0}^{N} (f_n - \mu)^3 P(f_n) \qquad (3)$$

Where,

δ^3 = Standard deviation of gray intensity value

Fn = Gray incensity

µ = Means

P(fn) = Histogram Value

3.4. Kurtosis

Show the degree of inclination of the relative histogram curve of an image

$$\alpha_4 = \frac{1}{\delta^4} \sum_{n=0}^{N} (f_n - \mu)^4 P(f_n) - 3 \qquad (4)$$

Where,

δ^4 = Standard deviation of gray intensity value

Fn = Gray incensity

µ = Means

P(fn) = Histogram Value

3.5. Entropy

Show the irregularities from of an image

$$H = -\sum_{n=0}^{N} P(f_n)\ ^2 log P(f_n) \quad (5)$$

Where,

P(fn) = Histogram Value

3.6. Algorithm Naive Bayes

$$P(C_i|X) = \frac{P(X|C_i)P(C_i)}{P(X)} \quad (6)$$

Where,

Ci = Hypothesis data on the specific class

X = Unknown Data

P(CiIX) = Probabilistic Hypothesis C with X

P(XICi) = Probabilistic Hypothesis X with C

P(Ci) = Probabilistic Hypothesis Ci

P(Ci) = Probabilistic Hypothesis Xi

The Data has a numerical value or Gaussian probability, with means and standard deviation on each class, with

$$g(X, \mu, \delta) = \frac{1}{\delta\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2(\delta^2)}} \quad (7)$$

So we have,

$$P(X_k|C_i) = g(X_i, \mu_i, \delta_i) \quad (8)$$

Table 1. Data on Normal Sollar Panel.

No	Means	Variants	Std	Medians
1	750.945	4,32E+03	1,87E+07	11.982.025
2	647.554	4.272	1,83E+07	8.736.300
3	460.565	2.712	7,36E+06	14.053.050
4	954.505	5.557	3,09E+07	20400850
5	822.386	3.368	1,13E+07	15201825
6	37.04.00	1.765	3,12E+06	6980200
7	434.877	2.864	8,20E+06	7876525
8	447.736	2.576	6,63E+06	7946225
9	447.736	2.576	6,63E+06	7946225
10	826.157	5.021	2,52E+07	8508500
11	506.401	3.616	1,31E+07	12698150
12	740.621	5.425	2,94E+07	16371000
13	638.957	3.338	1,11E+07	9577375
14	492.538	2.933	8,60E+06	7064350
15	654.361	4.368	1,91E+07	9559100
μ	588.356	3.647	14.508.812	10.993.447
σ	230979,09	1136,169804	8704169,5	3995844,17

Table 2. Data of Abnormal Solar Panel

No	Means	Varians	Std	Medians
1	447799	1685,2291	2839997	2.103.750
2	813442	5908,0911	34905541	25.488.950
3	1844662	1799,6391	3238701	36.581.025
4	606235	1782,5053	3177325	7035450
5	683362	7580,0838	57457671	12110375
6	667174	4607,0568	21224972	11074650
7	973785	3368,3281	11345634	16164025
8	1320077	5058,5155	25588579	24325300
9	699975	5344,6011	28564761	1065105216
10	903512	6953,5287	48351562	16324250
11	85824	4275,9325	18283599	17763725
12	727542	5133,4107	26351905	14389248
13	891236	3864,784	14936555	9448175
14	1026914	5107,2076	26083569	14750050
15	60643	4377,6952	19164215	17220575
μ	783478,8	4456,4406	22767639	85992317,6
σ	441054,3	1765,0708	15721234	270988335

The probability of Normal Solar Panel

$$P(Xi|Normal) = \frac{1}{\delta\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2(\delta^2)}} \quad (9)$$

If we hava some data (Abnormal11)

Means (X_1) = 85824

Std (X_2) = 4275,9325

Varians (X_3) = 18283599

Medians (X_4) = 17763725

$P(X_1|Normal) = \frac{1}{230979,1\sqrt{2(3,14)}} e^{\frac{-(85824-588,356)^2}{2(230979^2)}}$ = 0,000115684

$P(X_2|Normal) = \frac{1}{1136,1698\sqrt{2(3,14)}} e^{\frac{-(4275-3,647)^2}{2(1136,1698^2)}}$ = 0,002570263

$P(X_3|Normal) = \frac{1}{8704169,5\sqrt{2(3,14)}} e^{\frac{-(4275,93253-14508812)^2}{2(8704169,5^2)}}$ = 1,15409E-06

$P(X_4|Normal) = \frac{1}{3995844,17\sqrt{2(3,14)}} e^{\frac{-(17763725-10993447)^2}{2(3995844,17^2)}}$ = 2,6348E-06

The probabilityof Abnormal Solar Panel

$$P(Xi|Unnormal) = \frac{1}{\delta\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2(\delta^2)}} \quad (10)$$

If we have some data;
Means (X_1) = 85824
Std (X_2) = 4275,9325
Variants (X_3) = 18283599
Medians (X_4) = 17763725 (I think we should be consistent – unnormal doesn't sound correct, perhaps we should change all Unnormal to abnormal)

$P(X_1|Unnormal) = \frac{1}{441054,3\sqrt{2(3,14)}} e^{\frac{-(85824-783478,8)^2}{2(441054,3^2)}}$ = 1,98519E-05

$P(X_2|Unnormal) = \frac{1}{1765,0708\sqrt{2(3,14)}} e^{\frac{-(3115475-4456,4406)^2}{2(1765,0708^2)}}$ = 0,0000

$P(X_3|Unnormal) = \frac{1}{15721234\sqrt{2(3,14)}} e^{\frac{-(2,47E+14-22767639)^2}{2(15721234^2)}}$ = 0,0000

$P(X_4|Unnormal) = \frac{1}{270988335\sqrt{2(3,14)}} e^{\frac{-(17763725-85992317,6)^2}{2(270988335^2)}}$ = 0,0000

Posterior probability

$$P(C_i|X) = \frac{P(X|C_i)P(C_i)}{P(X)}$$

$$P(Normal|X_{uji})$$

= (1,15684E-3 x 2,570263E-2 x 1,15409E-06 x 2,6348E-06
= 9,03800216E-21

$P(Unnormal|X_{uji})$
=1,98519E-05 x 2,95912E10 x 4,5490E-6 x 9,5454E-8
= 3E-9

$P(Normal|X_{uji}) < P(Unnormal|X_{uji})$
Above proves that the data is Unnormal Solar panel

Based on the results of tests conducted on the applications made, the following conclusions can be drawn:

Table 1. Testing Section

	Correct	Incorrect
Normal Panel Surya	13	2
Unnormal Panel Surya	12	3
Accuracy	= 25/30 x 100% = 83 %	

4. Conclusion

Classification is a process that states a data object as one of the categories previously defined. The classification process used in the study is to use the Bayes theorem. The process begins with the learning process that requires input in the form of a labeled training data set so that it can issue output in the form of a classification model. The technique used is to use the Naive Bayes Classification. The amount of data used in this study amounted to thirty images consisting of fifteen broken solar panel images and fifteen images that were not damaged solar panels with an accuracy rate of eighty three percent. the results of this study are expected to be used as a reference for other classification methods. so that strategies can be found in the classification process that are simpler and have a higher level of accuracy.

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