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Detection of Mango Tree Varieties Based on Image Processing

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A B S T R A C T S

Mango is one of the most favourite fruits in the world. Therefore, this type of fruit has been researched deeply to enrich the variety. Here, the purpose of this study was to find the easiest method to determine the type and the variety of mango. In short of the experimental method, we analyzed the leaf using an image processing method. To confirm our result, several analyses were also conducted: leaves process digital image acquisition, and preprocessing, as well as feature extraction and classification. The result showed that our image processing method was effective to detect the variation of up to 78%. We believe that further study using this method will be effective for other types of fruits.

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1. INTRODUCTION

Research in the field of horticulture is now growing rapidly. (Permatasari *et al.*, 2016) Mango is one of the most favourite fruits in the world. Therefore, this type of fruit has been researched deeply to enrich the variety. (Hanson & Bell, 2007)

The goal of this study was to find the best way to determine the type of mango trees that have not been fruitful. The main part of the tree used in the research is the leaves. The leaves acquired into a digital image and then do the preprocessing, feature extraction, classification process is then performed to determine the type of the mango tree. Detection performance is 77.78% accuracy. Although that research do not provide optimal detection accuracy results, but Is showed that the detection of the mango tree species based on the texture of the image of the leaves is prospective.

Early studies on the mango tree species detection research was done by several researchers. For example, Prasetyo showed the accuracy is obtained up to 88.89%. The analysis for the selection of texture features were done and had been used in the test and repair the system. (Prasetyo, 2013; Prasetyo, 2016) The method used for the analysis is Fisher's Discriminant Ratio. The spectrum of colors used in these studies is gray. From the 17 candidates of the features used in the detection, 6 features are the most informative in the study. Performance testing of the system also provides better results that up to 90% accuracy.

As one part of the study, this research also analyzed the candidate features of image texture of mango leaves. Color component used is Hue component of the HSI spectrum. Candidates features used are 17 candidates, but the spectrum of colors used are different. Hue as the spectrum was used for generation of the features because Hue represents the pure color components of the digital image. (Camci *et al.*, 1992) The results of this analysis can prove that the features of the Hue spectrum can be used as an informative feature in detecting the type of a mango tree. (Usha & Singh, 2013) This is also confirmed by comparing the performance of the best features raised from Hue component to the new features.

Based on the above problems, this paper presented the results of research that analyzed candidate image texture features of mango leaves in Hue color components. Feature selection results in this research may be an additional feature detection system supporting the mango tree species.

2. CURRENT RESEARCH ON MANGO

Early studies on this research begins with a previous study, in which the main subject is the detection of a mango tree species that have not been fruitful based on digital image leaf texture of mango leaves. (Morales-Salazar *et al.*, 1997) The reason for the use of texture as the main feature for detection is the possibility for detecting the physical appearance of mango leaves by naked eye, the change in color can be distinguished easily. (Gomes & Leta, 2012) However, this cannot be done by layman due to their limitation. Proving empirically on results subsequent research (Prasetyo, 2013; Prasetyo, 2016), the detection system has a better accuracy that is 88.89%. This means that the in the system detection is quite high. Prasetyo also analyzed the informative features of leaf texture on the classification of types of mango trees. The result, from the 17 candidates features, showed 6 best features are recommended for use. Experiments with K-NN classification method also tends to provide better accuracy with value of 90%. Thus, the use of

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texture is reasonable for use in this study. This study also used features mature leaf color (*dark green*) as a base feature generated. Features color to a preliminary study of research to determine how much informative color in the detection of the type of mango leaves.

The successful method for detection is not only for one type of mango but also many types of mango, such as mango trees gadung and curut. The system can perform detection with accuracy performance of up to 77.78%. This result can be considered to be optimal. Improvement of the system is done by testing the classification method Support Vector Machine (SVM) and Fuzzy K-Nearest Neighbor in Every Class (FK-NNC). The results of application performance provides accuracy is up to 88.89%. This performance is much better than before. Further, the selection of the best features in the case of detection of a mango tree species, experiment with methods K-Nearest Neighbor (K-NN) obtained accuracy of 90%.

Maqbool *et al.* reported. that use of shape features as the main feature which is extracted from the leaves. (Maqbool *et al.*, 2015) Their research gave the performance of detection accuracy of from 96% to 98%. Kadu *et al.* reported the use of the YCbCr color as textual material to determine the type of disease in plants. (Kadu *et al.*, 2015) Kadir *et al.* segmented the image of mango. (Kadir *et al.*, 2015) Their research separated the object of mangoes. The method used is texture analysis and Randomized Hough Transform. Ganiron Jr. conducted research to determine the quality of mango fruit, but using the feature properties of mango fruit shape. The method used is Nearest Neighbor. (Ganiron Jr., 2014)

Ahmad focused quality classification based on the morphology physical properties of area and texture of the mango fruit. (Ahmad, 2010) Types of mango fruit observed was the type of gadung and arumanis, texture measurement used is the contrast of the red color index. The reason is because the color of ripe mango fruit is usually dominated by a somewhat reddish color on the skin. Accuracy obtained is about 74.3%.

Another research using the physical properties of texture made by Dhaygude and Kumbhar. (Dhaygude & Kumbhar, 2013). Leaf texture characteristics are used to detect the disease suffered by the tree.

Research conducted by Imaduddin and Tawakal showed detection of the type of leaf based on the shape and texture features. (Imaduddin & Tawakal, 2015) Classification method used is AdaBoost and Support Vector Machine. With the 1907 sample image of leaves, the system gives the performance accuracy of 66.91%. Though provide accuracy performance has not been good, but this study provides a different paradigm, in which the process of recognition/detection can be applied to mobile devices on Android operating system. Although the research is not yet mature in the development stage, the opportunity to develop a detection system in another horticulture is high. Other studies have similar scheme is Sanjana *et al.*, which used the feature shape, color, and texture of the leaves to detect diseases in plants. (Sanjana *et al.*, 2015) Yamamoto *et al.* published results of research to detect maturity for tomatoes by color, shape, texture, and size. (Yamamoto *et al.*, 2014) System performance is obtained has a recall value of 80% and precision of 88%.

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3. RESEARCH METHODOLOGY

Research results presented in this paper on the analysis and selection of texture features are extracted from a digital image of mango leaves. There are 3 types of features conducted the analysis: statistics, invariant moment, and the co-occurrence matrix. From statistics feature, a feature that is processed is the average intensity, contrast, smoothness, third moment, uniformity, and entropy. From the moment invariant feature being processed is 7 invariant moments. While the co-occurrence matrix feature that is processed is the entropy, energy, contrast, and homogeneity. These features extracted from Hue component of the spectrum HSI. Feature analysis performed using Fisher's Discriminant Ratio (FDR) is to get to the classification features informative. The analysis was also conducted separately between features. Assumptions used in this study are as follows:

1. The image processing feature extraction has been done through the segmentation process. So that, part of the image that is not leaf will be given black color.
2. The number of images used in this study is 60 pieces, divided into 30 types of gadung mango and 30 types of mice mango.
3. HIS components are Hue, is Hue component used can be to represent content of pure color without being influenced by anything.
4. Analysis feature performed on each of the features individually, so that between one feature to another feature will not have any relationship.
5. The threshold used as an informative feature are FDR with index value ≥ 0.5.
6. Testing the performance of the system with the selected feature used K-Nearest Neighbor method.

This research done by following the research framework as follows:

1. Doing literature study of detection of mango tree species and features analysis

   At this stage the author read up literature of a number of studies, both concerning the detection of mango tree species, as well as the detection of another object. Book study of the methods for the selection of features will also be necessary to determine the appropriate method to use. For the analysis of mango leaf texture feature will use Fisher's Discriminant Ratio.

2. Extraction of features in the HSI spectrum

   At this stage, the authors do image conversion from RGB to HSI, further making Hue component. The next process is the extraction of texture features Hue component. There are 30 images of gadung mango leaves and 30 images of mice mango. Statistical texture features extracted is the average intensity, contrast, smoothness, third moment, uniformity, and entropy. From the moment invariant texture, a feature which is extracted is 7 moment invariant, while the co-occurrence matrix texture features entropy, energy, contrast, and homogeneity.

3. Calculations of feature selection using FDR

At this stage, the authors calculated the value of FDR to all the features. FDR value is calculated separately for each feature, where each feature on a number of data is correlated with the class label.

4. The selection of informative features based on the FDR index value

   The author makes the selection a number of informative features based on the FDR index value of all features that is greater than or equal to the threshold (threshold is 0.5) If the FDR value of a feature is greater than or equal to the threshold value than the feature it.

5. Comparative test and analysis

   At this stage, the authors conducted a comparative test using that passed FDR feature selection versus old features. Classification method used is K-NN. After testing the performance analysis of results was obtained in both types of features.

4. RESEARCH RESULT AND ANALYSIS

4.1 Data Set

There are 17 candidates features extracted. All of these features are extracted from Hue component of HSI spectrum. The number of images used are 60 data consists of 30 species for gadung mango and 30 species for mango curut (= Java). The data set used are presented in **Table 1.**

4.2. FDR Index Value and Analysis

Furthermore, the calculation of FDR index value of each feature by calculating on each and every group class features such as average and variance, then calculated the FDR index value. The results are as shown in **Table 2**.

FDR index values gives an overview of the level of feature capabilities that can separate data between two classes. Minimum FDR index value is 0, which states that the feature can not fully separate data between two classes. Values higher mark feature that can separate data between two classes better. On the 17 candidates feature, only two features qualify the threshold 0.5, which is uniformity (statistics) and energy (co-occurrence matrix), each having FDR index value of 1.221 and 1.464.

None of the moment invariant that passed the selection because FDR index value that is far below the threshold. It also means that the moment invariant texture features is less suitable as a feature in detection of mango tree species based on the texture of the leaves. It has also been proven as in previous studies.

4.3. Comparative Test and Analysis

Furthermore, the comparison between the selected features with the features used in previous studies. The comparison was done to the features used in several reports.

Comparison of features that are used are presented in **Table 3.** The three groups of features are then used for prediction using K-NN with a choice of a number of value of K nearest neighbors.

Tabel 1. Dataset tekstur yang dibangkitkan dari komponen Hue.

No	Statistik						Moment Invariant							Matrik Co-occurrence				Kelas
	rata-rata	kontras	smooth ness	third moment	uni formity	entropy	moment 1	moment 2	moment 3	moment 4	moment 5	moment 6	moment 7	entropy	energy	kontras	homo genitas	
1	62.869	1.352	0	0.0001	0.386	1.669	0.280	0.249	13.359	13.301	26.672	13.202	27.908	0.626	0.357	0.257	0.956	1
2	62.928	1.392	0	0.0005	0.398	1.642	0.258	0.191	12.192	12.121	24.279	12.080	27.054	0.613	0.371	0.368	0.958	1
3	62.490	1.777	0	0.0003	0.394	1.680	0.163	0.095	11.820	11.426	23.049	11.475	27.151	0.612	0.371	0.482	0.964	1
4	62.556	1.755	0	0	0.416	1.603	0.128	0.204	11.885	11.430	23.088	11.554	26.969	0.581	0.394	0.131	0.967	1
5	62.745	1.541	0	0	0.408	1.644	0.144	0.147	16.312	14.964	30.723	15.410	31.523	0.599	0.386	0.115	0.966	1
6	62.603	1.759	0	0.0005	0.392	1.730	0.129	0.198	17.286	16.081	32.999	18.550	33.405	0.632	0.370	0.600	0.963	1
7	62.342	1.955	0.0001	0.0002	0.378	1.764	0.190	0.019	13.254	14.461	28.860	14.892	28.642	0.661	0.350	0.434	0.953	1
8	62.501	1.881	0.0001	-0.0001	0.413	1.669	0.149	0.141	13.992	13.486	27.290	13.779	28.281	0.616	0.390	0.114	0.960	1
9	62.475	1.697	0	0.0007	0.346	1.822	0.159	0.108	12.284	13.974	27.340	14.442	28.227	0.670	0.318	0.519	0.960	1
10	62.414	1.790	0	0.0009	0.337	1.873	0.155	0.122	15.765	14.309	29.509	14.474	29.984	0.695	0.308	0.681	0.956	1
11	62.490	1.602	0	0.0001	0.344	1.837	0.163	0.095	13.963	13.456	27.209	13.537	28.404	0.686	0.313	0.286	0.954	1
12	62.496	1.603	0	0	0.352	1.817	0.139	0.168	14.602	14.300	28.873	14.441	29.517	0.677	0.322	0.133	0.955	1
13	62.716	1.486	0	0	0.400	1.604	0.116	0.236	14.924	16.195	31.791	16.480	33.231	0.592	0.373	0.102	0.962	1
14	62.682	1.498	0	0.0001	0.376	1.696	0.128	0.200	16.362	17.127	34.208	17.433	34.372	0.631	0.347	0.255	0.958	1
15	62.644	1.536	0	0	0.396	1.633	0.145	0.148	15.353	14.737	29.935	14.816	30.614	0.609	0.367	0.123	0.958	1
16	62.566	1.575	0	0	0.394	1.631	0.144	0.151	13.828	15.854	31.318	16.714	31.105	0.608	0.365	0.155	0.959	1
17	62.187	1.942	0.0001	0	0.359	1.781	0.007	0.687	13.733	13.659	27.358	14.442	29.949	0.653	0.333	0.122	0.961	1
18	62.143	1.977	0.0001	-0.0001	0.359	1.782	0.013	0.615	13.347	14.002	27.926	16.407	28.142	0.657	0.332	0.175	0.960	1
19	62.238	1.954	0.0001	0	0.374	1.734	0.005	0.678	13.258	13.300	26.659	14.407	27.540	0.631	0.350	0.110	0.964	1
20	62.298	1.926	0.0001	-0.0001	0.380	1.723	0.002	0.649	12.258	12.889	25.886	15.289	25.742	0.642	0.352	0.177	0.956	1
21	62.439	1.756	0	0	0.374	1.752	0.148	0.142	12.788	12.135	24.599	12.208	27.237	0.659	0.344	0.160	0.952	1
22	62.480	1.748	0	0	0.384	1.723	0.132	0.191	12.430	12.114	24.389	12.290	27.113	0.640	0.358	0.132	0.958	1
23	62.430	1.806	0.0001	0	0.382	1.725	0.154	0.126	11.821	11.339	22.919	11.406	27.356	0.648	0.354	0.160	0.954	1
24	62.263	1.909	0.0001	0.0007	0.338	1.882	0.184	0.037	11.710	11.314	22.826	11.348	26.665	0.712	0.304	0.627	0.946	1
25	62.204	1.988	0.0001	0	0.368	1.761	0.027	0.556	12.560	11.774	24.041	12.171	24.993	0.655	0.340	0.155	0.955	1
26	62.769	1.534	0	0.0003	0.399	1.646	0.021	0.556	12.445	11.943	24.158	12.223	25.944	0.615	0.371	0.464	0.957	1
27	62.525	2.324	0.0001	0.0049	0.369	1.794	0.021	0.568	12.645	12.625	25.352	13.278	26.149	0.673	0.340	2.751	0.952	1
28	62.501	1.796	0	0.0009	0.375	1.723	0.045	0.482	12.416	12.189	24.517	12.662	25.981	0.655	0.343	0.719	0.951	1
29	62.480	2.246	0.0001	0.0038	0.364	1.796	0.031	0.533	13.027	12.906	25.934	13.490	26.953	0.677	0.334	2.314	0.950	1
30	62.456	2.164	0.0001	0.0036	0.362	1.799	0.035	0.518	12.649	12.648	25.379	13.283	26.233	0.677	0.331	1.785	0.951	1
31	62.491	1.633	0	0	0.392	1.618	0.074	0.382	11.469	11.349	22.778	11.548	24.359	0.592	0.366	0.123	0.965	2
32	63.033	3.708	0.0002	0.0237	0.395	1.603	0.118	0.223	10.411	10.244	20.572	10.378	24.831	0.594	0.367	6.112	0.961	2
33	62.700	1.329	0	0	0.352	1.697	0.033	0.515	14.034	14.312	28.553	14.570	29.689	0.631	0.319	0.106	0.958	2

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Tabel 1 (continue). Dataset tekstur yang dibangkitkan dari komponen

No	Statistik						Moment Invariant							Matrik Co-occurrence				Kelas
	rata-rata	kontras	smoothness	third moment	uniformity	entropy	moment 1	Moment 2	moment 3	moment 4	moment 5	moment 6	moment 7	entropy	energy	kontras	homogenitas	
34	62.702	1.456	0	0.0007	0.350	1.710	0.006	0.614	13.278	13.403	26.743	13.731	30.137	0.634	0.317	0.461	0.959	2
35	62.673	1.633	0	0.0014	0.347	1.695	0.001	0.640	11.385	11.243	22.560	11.563	25.161	0.627	0.314	1.479	0.960	2
36	62.666	1.597	0	0.0015	0.346	1.703	0.021	0.719	11.405	11.204	22.513	11.565	25.120	0.629	0.313	0.920	0.960	2
37	62.667	1.372	0	0.0003	0.335	1.771	0.068	0.395	11.231	11.126	22.305	11.327	27.365	0.653	0.303	0.360	0.960	2
38	62.640	1.523	0	0.0007	0.332	1.795	0.068	0.394	11.871	11.804	23.645	12.005	26.275	0.661	0.301	1.010	0.960	2
39	62.812	2.271	0.0001	0.007	0.364	1.660	0.068	0.388	12.651	12.500	25.080	12.703	27.631	0.623	0.330	3.220	0.956	2
40	62.721	1.571	0	0.0011	0.361	1.671	0.063	0.408	12.744	12.840	25.635	13.045	28.536	0.625	0.327	0.832	0.957	2
41	62.738	2.265	0.0001	0.0064	0.355	1.680	0.079	0.355	12.986	13.014	26.046	13.292	27.573	0.630	0.320	2.794	0.956	2
42	62.763	2.034	0.0001	0.0044	0.364	1.666	0.045	0.473	12.949	12.941	25.892	13.184	28.275	0.625	0.329	3.166	0.955	2
43	62.381	1.708	0	0.0005	0.340	1.811	0.080	0.362	16.552	14.979	30.752	15.840	33.021	0.676	0.308	0.664	0.955	2
44	62.331	1.869	0.0001	0.0017	0.334	1.827	0.079	0.367	15.447	15.367	31.100	16.946	31.141	0.687	0.299	1.526	0.952	2
45	62.316	1.785	0	0.0009	0.331	1.841	0.098	0.306	14.695	13.878	28.222	14.585	29.270	0.693	0.296	0.829	0.951	2
46	62.341	1.777	0	0.0009	0.335	1.824	0.084	0.351	15.273	15.114	30.647	17.300	30.662	0.686	0.301	0.684	0.952	2
47	62.453	1.583	0	0	0.352	1.772	0.161	0.102	12.159	12.157	24.319	12.220	26.921	0.660	0.321	0.102	0.957	2
48	62.469	1.660	0	0.0008	0.352	1.752	0.167	0.082	11.968	11.851	23.769	11.893	25.768	0.664	0.315	0.783	0.951	2
49	62.429	1.580	0	0	0.350	1.772	0.151	0.133	11.707	11.673	23.365	11.748	26.300	0.664	0.317	0.110	0.954	2
50	62.407	1.763	0	0.0012	0.349	1.775	0.172	0.069	12.027	11.959	23.957	11.993	26.207	0.670	0.314	0.795	0.952	2
51	62.526	1.531	0	0.0004	0.348	1.711	0.071	0.387	11.492	11.530	23.050	11.723	25.043	0.637	0.315	0.472	0.958	2
52	62.449	1.422	0	0	0.340	1.721	0.043	0.486	12.084	11.984	24.077	12.251	25.109	0.640	0.305	0.110	0.959	2
53	62.415	1.426	0	0	0.338	1.732	0.059	0.430	11.622	11.646	23.294	11.861	25.050	0.641	0.304	0.105	0.961	2
54	62.372	1.412	0	0	0.331	1.752	0.066	0.409	11.578	11.715	23.373	11.920	25.277	0.657	0.292	0.118	0.957	2
55	62.552	2.216	0.0001	0.0059	0.316	1.844	0.006	0.664	12.309	12.422	24.788	12.757	28.076	0.677	0.285	2.116	0.961	2
56	62.560	1.774	0	0.0024	0.319	1.819	0.003	0.650	11.937	11.924	23.868	12.289	25.896	0.664	0.288	2.147	0.963	2
57	62.741	1.483	0	0.0012	0.352	1.723	0.026	0.735	12.977	12.964	25.997	13.367	27.184	0.648	0.316	1.174	0.955	2
58	62.742	1.351	0	0.0003	0.352	1.720	0.007	0.659	12.985	12.972	25.969	13.302	27.783	0.636	0.320	0.445	0.960	2
59	62.656	1.282	0	0	0.338	1.769	0.012	0.590	12.149	12.045	24.172	12.362	25.758	0.670	0.299	0.125	0.951	2
60	62.515	1.440	0	0.0003	0.319	1.836	0.015	0.585	11.051	10.944	21.946	11.237	24.484	0.691	0.281	0.284	0.952	2

Tabel 2. Feature Candidate

No.	Type	Feature	FDR	Rank
1.	S	Average	0.089	12
2.	S	Contrast	0.014	15
3.	S	Smoothness	0.055	13
4.	S	third moment	0.109	11
5.	S	Uniformity	1.221	2
6.	S	Entropy	0.012	16
7.	M	Moment 1	0.294	3
8.	M	Moment 2	0.223	6
9.	M	Moment 3	0.202	7
10.	M	Moment 4	0.227	5
11.	M	Moment 5	0.239	4
12.	M	Moment 6	0.202	8
13.	M	Moment 7	0.155	10
14.	C	Entropy	0.021	14
15.	C	Energy	1.464	1
16.	C	Contrast	0.178	9
17.	C	homogeneity	0.001	17

Information:
S : Statistic M : Moment Invariat C : Co-occurence Matrix

Tabel 3. Features used as a comparison test of classification performance

Old Feature (Agustin and Prasetyo, 2011)	New Feature (Prasetyo, 2012)	Feature of Research Result
average (S)	third moment (S)	uniformity (S)
Smoothness (S)	uniformity (S)	energy (C)
entropy (S)	Entropy (S)	
Moment 1 (M)	Entropy (C)	
Moment 2 (M)	energy (C)	
Moment 4 (M)	homogeneity (C)	
Moment 6 (M)		
Moment 7 (M)		
energy (C)		
Contrast (C)		

Comparative testing was conducted using K-NN with K = 1, K = 3, K = 5, K = 7, K = 9, and K = 11. At each test session, there are 12 data into test data, and the rest goes to the training data. Before being used for classification, all data were normalized to provide the same range of values. Normalization used is zero-mean. Testing system is done by using the K-Fold Cross Validation. Number of fractions (K) used in each experiment K-Fold is 5. This is done as much as 5 times the experiment as well. The results are then calculated the average to get all performance. K-NN prediction by using Eulidean distance.

Testing system is done by using the K-Fold Cross Validation. Number of fractions (K) used in each experiment of K-Fold is 5.

This is done as much as 5 times experiment as well. The result is then calculated to obtain average overall performance.

Two features obtained in this study is already included in the selected feature in previous studies, but that study were conducted on the gray spectrum, whereas in this study conducted at the Hue component. In this study, four features are studied: third moment (S), entropy (S). entropy (C), and homogeneity (C) these feature did not pass the selection FDR index. This study also conducted observation on the effect of four of these features during the classification.

Tabel 4 shows prediction result by K-NN. From the test results as shown in this table, the performance prediction accuracy for features of these research results are not too good. For example, for K = 1, features research results are worse than the old features (0.77 vs 0.90), while for K = 5, features research results are better than the old features (0.80 vs 0.76). New features also tested by applying it to the Hue component. Comparison of the accuracy of the new features, it turns out the new features that is better than new features on the Hue component.

Tabel 4. Prediction result by K-NN

Old Feature

Experiment	K = 1	3	5	7	9	11
1	0.90	0.88	0.78	0.80	0.80	0.80
2	0.92	0.78	0.78	0.75	0.75	0.77
3	0.88	0.82	0.73	0.77	0.80	0.78
4	0.88	0.82	0.68	0.77	0.73	0.70
5	0.90	0.85	0.83	0.80	0.82	0.75
Average	0.90	0.83	0.76	0.78	0.78	0.76

New Feature (Prasetyo, 2015)

Experiment	K = 1	3	5	7	9	11
1	0.87	0.90	0.85	0.87	0.87	0.85
2	0.88	0.87	0.88	0.88	0.85	0.85
3	0.88	0.90	0.92	0.87	0.85	0.83
4	0.85	0.85	0.87	0.85	0.85	0.83
5	0.93	0.92	0.90	0.87	0.87	0.83
Average	0.88	0.89	0.88	0.87	0.86	0.84

Feature of Research Result

Experiment	K = 1	3	5	7	9	11
1	0.78	0.78	0.78	0.83	0.83	0.80
2	0.77	0.73	0.80	0.83	0.83	0.82
3	0.75	0.75	0.80	0.85	0.83	0.80
4	0.75	0.73	0.78	0.80	0.80	0.78
5	0.80	0.80	0.82	0.83	0.83	0.80
Average	0.77	0.76	0.80	0.83	0.83	0.80

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New features are selected by FDR testing, which is uniformity (S) and energy (C). These factors are also already contained in the selected feature from our previous study. There are other features of previous studies that did not pass the selection with FDR, but the contribution of these features is helpful in providing better performance.

4.4 Performance Test 6 Best Features

Proving that the performance of the new features is better than the texture features of the Hue component in this research. This also gives evidenced by the performance of comparison test. Performance testing is done by predicting the K-NN method. Testing systems also used the same way in the previous section.

Features used to the new features are 6 features selected from our previous studies: third moment (S), uniformity (S), entropy (S), entropy (C), energy (C), homogeneity (C). And, other the features of the research results used are energy (C), uniformity (S), moment 1 (M), moment 5 (M), Moment 4 (M) and moment 2 (M). The results are presented in **Tables 5 and 6 .**

Tabel 5. Performance Test 6 New Features

New Feature						
Experiment	K					
	1	3	5	7	9	11
1	0.92	0.88	0.85	0.85	0.83	0.82
2	0.82	0.83	0.85	0.85	0.82	0.80
3	0.85	0.90	0.88	0.87	0.87	0.85
4	0.92	0.90	0.90	0.83	0.82	0.82
5	0.90	0.90	0.88	0.88	0.85	0.85
Average	0.88	0.88	0.87	0.86	0.84	0.83

Tabel 6. Performance Test 6 Features of Research Result

Feature of Research Result						
Experiment	K					
	1	3	5	7	9	11
1	0.90	0.80	0.78	0.70	0.72	0.77
2	0.88	0.80	0.73	0.60	0.67	0.72
3	0.95	0.77	0.75	0.70	0.67	0.67
4	0.92	0.87	0.70	0.70	0.72	0.75
5	0.88	0.82	0.77	0.70	0.70	0.72
Average	0.91	0.81	0.75	0.68	0.69	0.72

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The results given in **Tables 5 and 6** proved that the performance of the new features was always better than the features used in this research. In the performance of K = 3, K = 5, K = 7, K = 9 and K = 11, the accuracy obtained new features is always better than the features in this research. It also confirmed that the new features in previous studies can also be used on components in the Hue HSI spectrum.

From the exposure in the previous section, it can be concluded that two of the best features and the 6 best features extracted from Hue components can not work optimally, while the feature generated by previous research would still work optimally when applied to the Hue component of the spectrum HSI image.

5. CONCLUSIONS AND SUGGESTIONS

From the research done, we concluded several information:

1. The best Features of mango leaves image texture extracted from Hue components are energy (C), uniformity (S), one moment (M), 5 moment (M), 4 moment (M), and a second moment (M). However, the factors cannot provide optimal performance. In the K-NN method, accuracy can reach up to 0.83 (83%).
2. Features of mango leaves image texture are third moment (S), uniformity (S), entropy (S), entropy (C), energy (C), homogeneity (C) which is extracted from the gray spectrum. These parameters become the best selected feature in detection of the type of a mango tree.
3. Features of mango leaves image texture can provide optimum performance accuracy. In the K-NN method, accuracy can reach up to 0.89 (89%).

Regarding suggestions, we summarized in the following:

1. The results of this study is limited to two species of mango trees, which is gadung and mice, as researchers used previously. This, we need to use other types of mango leaves to provide extended coverage mango species.
2. Testing the performance of the new system is done on one method, K-NN, However it is, necessary to provide test for getting the performance of the other methods, such as Support Vector Machine, Artificial Neural Network, or etc.
3. We still need more amount of data in testing sessions to provide a more credible performance.

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7. AUTHOR'S NOTES

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article. Authors confirmed that the data and the paper are free of plagiarism.

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