Fruits Classification from Image using MPEG-7 Visual Descriptors and Extreme Learning Machine

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***Abstract*—Fruit image classification has several applications and can be used as alternative to traditionally fruit classification performed by human expert. This paper aims to propose fruits classification method from image using extreme learning machine (ELM), MPEG-7 visual descriptors, and principle component analysis (PCA). The optimum parameters of ELM and PCA were determined using grid search optimization. The best classification performance of 97.33% has been achieved in classifying Indonesian fruit images consisted of 15 classes. By applying the ensemble of ELMs, the classification accuracy was increased to 98.03%. This result shows that the proposed method produces high classification performance.**

Keywords*— *Indonesian fruit; fruit image; extreme learning machine; MPEG-7 visual descriptors; classification

I. Introduction

There are several tropical fruits grown and traded in Indonesia. Due to similarities in visual appearance, some Indonesian fruits are difficult to be recognized manually by inexpert person [1], such as Pacitan orange and Siam lime. To overcome this problem, fruits classification from image can be considered as alternative to manual fruit recognition. Fruits classification from image has various applications, such as for fruit pricing in supermarket [2], fruit sorting [3] and grading [4] in food industry, as well as fruit maturity identification [5].

Several fruits classification methods from image have been proposed in the previous studies. The methods can be categorized into two groups, fruits classification for same variety [3]–[6] and fruits classification for different variety [1], [7]–[17]. Various features and classifiers have been employed in fruits image classification. In some previous studies, segmentation process was used to divide the pixels in fruit image into fruit pixels and background pixels before feature extraction process, although the image has a homogeneous background. However, this process may increase the time required for classification.

Studies in [7] and [12] have proposed fruit classification methods by extracting morphology based shape measure features, Unser's features, and color histogram from the fruit image. Split and merge algorithm was applied in segmentation process before features extraction. Since the image contains several fruit objects, the proposed method needed to determine the region in the image which only contains a fruit object to extract the shape features. This step will also increase the computation time. The dimension of extracted features was reduced using principle component analysis (PCA) before inputted to classifier. Feed forward neural network trained with various metaheuristic optimization methods was used for classification. The proposed methods were used to classify 18 classes fruit and only achieved the highest accuracy of 89.11% with 5-folds cross validation. Study in [10] has proposed fruit classification methods similar to the methods proposed in [7] and [12] but using wavelet entropy features extracted from every channel in RGB image. However, the accuracy of the proposed method is only 89.5%.

Shape features based on the derivative of radius function and statistical color features were used in [11] and [13] to classify natural produce from image. Automatic thresholding was applied to segment fruit object and its background. The classification method in [11] used artificial neural network (ANN) and obtained accuracy of 99.87% in classifying three classes natural produce. On the other hand, the classification method in [13] used ANN combined with a linear model trained using Kalman filter [18] for classifying natural produce image consisted of 10 classes and achieved accuracy of 98.4%. However, both proposed methods cannot be used to classify fruit image with more than one object.

Recently, deep neural network was also employed to classify fruit image, as reported in [9], [14]–[17]. Although deep learning model can achieve classification accuracy more than 90%, it required high computer resources and high computational cost in training process [15]. Furthermore, segmentation process was still performed on the fruit image before inputted to deep neural network to achieve a good accuracy as reported in [14], [15] and [16].

Moving Picture Experts Group-7 (MPEG-7) visual descriptors [19] have been used for fruits classification from image in some study [1], [8]. MPEG-7 descriptor is a multimedia content descriptor consisted of audio and visual descriptors that can be used to describe multimedia data [20]. By using MPEG-7 visual descriptors, the classification process of fruit image does not require preprocessing and segmentation processes [8]. An image based Indonesian fruit classification method has been proposed in [8] using *k*-nearest neighbor (*k*-NN) and MPEG-7 color structure descriptor. To reduce the computational complexity during training and testing processes, some features in the descriptor was excluded using variance base feature selection. The best accuracy of 90.86% was obtained in classifying seven classes fruits image.

To increase the performance of Indonesian fruits image classification, the ensemble of *k*-NN and linear discriminant analysis (LDA) trained with combination of MPEG-7 color and texture descriptors has been used in [1]. PCA was used to decrease the length of feature vector in the combination before used in classification. The best accuracy of 97.80% was achieved in classifying 15 classes Indonesian fruits image. However, the parameters of LDA and k-NN used in [1] were not optimized.

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In the previous studies, fruits image classification based on MPEG-7 visual descriptor only employed simple classifiers. Therefore, there is a possibility to increase classification accuracy by applying more complex classifiers such as extreme machine learning (ELM) [21]. ELM is a three layers feed forward neural networks. The first layer is input layer which corresponds to input features, the second layer is hidden layer, and the last is output layer which corresponds to output class. During training process, the weights and biases of ELM from the first layer to the second layer are randomly generated once and do not need to be updated. The weights of ELM from the second layer to the last layer can be easily calculated without iteration process. Furthermore, ELM has been applied to solve both prediction [22]–[24] and classification [25]–[27] problems in various field.

This paper proposes a fruit image classification method using constrained-optimization-based ELM, MPEG-7 visual descriptors and PCA. To obtain a good classification performance, the parameters of ELM and PCA were determined using grid search optimization.

II. Materials and Method

A. Image data set

The proposed method was validated using Ubaya-IFDS3000 data set proposed in [1]. The data set contained of 15 classes Indonesian fruits namely Star fruit, Soursop, Siam lime, Sapodilla, Salak, Pineapple, Persimmon, Pacitan orange, Mangosteen, Guava, Durian, Duku, Dragon fruit, Avocado, and Ambarella. Each class consisted of 200 images captured with the dimension of 2,592 × 1,456 pixels in RGB color space and saved in JPEG format.

The image had light blue, light green, light yellow, pink, and white background. It was captured using two intensities illumination sources (1,050 lm and 160 lm) with two camera orientations (0^o and 45^o). To increase the complexity, the number of objects varied and there were shadows near some objects in each image. Fig. 1 shows some images in the Ubaya-IFDS3000 data set.

B. Method

The proposed fruits classification method comprised three successive processes, including features extraction, dimensional reduction, and classification. The explanations for every process are as follow.

1) Features extraction

Five MPEG-7 visual descriptors were extracted in this process. Segmentation process was not required before this process due to each image in Ubaya-IFDS3000 data set has homogenous background. Therefore, feature extraction could be directly performed in the whole image. The extracted descriptors consisted of color structure descriptor (D_1), scalable color descriptor (D_2), color layout descriptor (D_3), edge histogram descriptor (D_4) and homogeneous texture descriptor (D_5).

Color structure descriptor is a color histogram in HMMD color space with 256 colors. It is used to describe the color distribution and the local color structure of the fruit image. Scalable color descriptor is a color histogram extracted in HSV color space with 256 color. The histogram is normalized, nonlinearly mapped into four-bit integer representation, and coded using Haar transform. Color layout descriptor is used to represent the spatial color distribution of fruit image. It is constructed by transforming 2D array of local representative color of the image, which is the average of pixel intensities in YCbCr color space, using discrete cosine Fourier transform (DCT). Color layout descriptor is obtained by nonlinearly quantizing some DCT coefficients in low frequency.

Fig. 1. Some fruits images in Ubaya-IFDS3000 data set

Edge histogram descriptor contains spatial edge distribution of the fruit image. The image was portioned into 4×4 nonoverlapping sub region and then the local edge distribution was extracted from every sub region. From every sub region five edge categories, including vertical, horizontal, 45^o diagonal, 135^o diagonal, and nondirectional edge, were extracted using appropriate five edge detectors. Homogeneous texture descriptor uses the mean and the deviation of energy from a set of channels in 2D frequency after transformed with Gabor filtered Fourier. The detail explanation about MPGE-7 descriptors extraction can be found in Manjunath et al. [18]. In this study the total number of extracted features was 774, consisted of 256 features from D_1, 256 features from D_2, 120 features from D_3, 80 features from D_4 and 62 features from D_5.

The proposed method used MPEG-7 Low Level Feature Extraction Static/Dynamic Library [20] and OpenCV 2.3.1 [28] in extracting MPEG-7 visual descriptors. In this study, the combinations of descriptors used for classification were the combinations that achieve classification accuracy more than 90% in classifying Indonesian fruit image reported in [1], as tabulated in TABLE I.

2) Dimensional reduction

A huge number of features does not guarantee a classifier achieves the best performance. Moreover, this condition can also increase both complexity and computational time in classifier training process. To overcome this problem, PCA was employed to decrease the length features before classification proses [29]. PCA is categorized as unsupervised method that works by transforming the input features vector to a new vectors in another space, called principle components, using a linear transformation based on the eigenvectors of input features covariance matrix $\mathbf{\Sigma}$, as shown (1),

$$\mathbf{X}_{pc} = (\mathbf{X} - \boldsymbol{\mu})\mathbf{V} \quad (1)$$

where $\mathbf{X}$ and $\boldsymbol{\mu}$ are the input features vector and its mean, respectively, $\mathbf{X}_{pc}$ is principle components, and $\mathbf{V}$ is the eigenvectors of $\mathbf{\Sigma}$.

TABLE I. THE COMBINATION OF MPEG-7 DESCRIPTORS USED FOR CLASSIFICATION

i	Combination of Descriptors (C_i)	i	Combination of Descriptors (C_i)
1	D_1	13	D_1, D_3, D_4
2	D_2	14	D_1, D_3, D_5
3	D_1, D_2	15	D_1, D_4, D_5
4	D_1, D_3	16	D_2, D_3, D_4
5	D_1, D_4	17	D_2, D_3, D_5
6	D_1, D_5	18	D_2, D_4, D_5
7	D_2, D_3	19	D_1, D_2, D_3, D_4
8	D_2, D_4	20	D_1, D_2, D_3, D_5
9	D_2, D_5	21	D_1, D_2, D_4, D_5
10	D_1, D_2, D_3	22	D_1, D_3, D_4, D_5
11	D_1, D_2, D_4	23	D_2, D_3, D_4, D_5
12	D_1, D_2, D_5	24	D_1, D_2, D_3, D_4, D_5

After transformation, all principle components are ordered based on the order of eigenvalues of $\mathbf{\Sigma}$ in decreasing order and are not correlated with each other. To perform dimensional reduction, PCA selects some first few principle components as reduced features while maintaining the variability of the input features. To guarantee there is no domination from some features to the others, each reduced feature was then scaled to the range $[0,1]$. The following equation was used to transform each reduced feature to the range $[0,1]$,

$$x_s = \frac{x_r - \text{minimum}(x_r)}{\text{maximum}(x_r) - \text{minimum}(x_r)} \quad (2)$$

where x_r and x_s are reduced and scaled features, respectively

The dimension of reduced features used in classification was determined such that the proportion of the variation that needs to be explained is greater than p for some value p. The value of p was determined using grid search optimization in the range $[0.88, 0.99]$ with increment 0.01. In this study, dimensional reduction using PCA was performed using scikit-learn 0.20.3 library [30].

3) Classification

This study employed constrained-optimization-based ELM [21] to classify Indonesian fruit image using the combination of MPEG-7 color and texture descriptor as input features. The output of ELM is obtained by multiplying the second layer output $\mathbf{g}(\mathbf{x}) = [g_1(\mathbf{x}), g_2(\mathbf{x}), \dots, g_n(\mathbf{x})]$ with respect to input $\mathbf{x} = [x_1, x, \dots, x_m]$ and the weight from the second layer to the last layer $\boldsymbol{\beta} = [\beta_1, \beta_2, \dots, \beta_n]^T$ as in the following equation,

$$\mathbf{f}(\mathbf{x}) = \mathbf{g}(\mathbf{x})\boldsymbol{\beta} \quad (3)$$

where m and n are the dimension of input and the number of nodes in the second layer, respectively.

ELM training aims to determine the output weight $\boldsymbol{\beta}$ that minimizes the ELM output error and the norm of $\boldsymbol{\beta}$ as formulated in the following equation,

$$\text{Minimize: } \|\mathbf{G}\boldsymbol{\beta} - \mathbf{Y}\| \text{ and } \|\boldsymbol{\beta}\| \quad (4)$$

where $\mathbf{G}$ is the second layer output matrix for all training data,

$$\mathbf{G} = \begin{bmatrix} \mathbf{g}(\mathbf{x}_1) \\ \mathbf{g}(\mathbf{x}_2) \\ \vdots \\ \mathbf{g}(\mathbf{x}_N) \end{bmatrix} = \begin{bmatrix} g_1(\mathbf{x}_1) & g_2(\mathbf{x}_1) & \cdots & g_n(\mathbf{x}_1) \\ g_1(\mathbf{x}_2) & g_2(\mathbf{x}_2) & \cdots & g_n(\mathbf{x}_2) \\ \vdots & \vdots & \ddots & \vdots \\ g_1(\mathbf{x}_N) & g_2(\mathbf{x}_N) & \cdots & g(\mathbf{x}_N) \end{bmatrix} \quad (5)$$

$\mathbf{Y} = [\mathbf{y}_1^T, \mathbf{y}_2^T, \dots, \mathbf{y}_N^T]$ is the expected output matrix for all training data, $\mathbf{y}_i = [y_{i1}, y_{i2}, \dots, y_{ik}]^T, i = 1,2,\dots,N$, N is the number of training data and k is the dimension of ELM output. In classification problem the value of $y_{ij}, j = 1,2,\dots,k$, is defined as in (6)

$$y_{ij} = \begin{cases} 1, i^{th} \text{ training data belongs to } j^{th} \text{ class} \\ 0, \text{otherwise.} \end{cases} \quad (6)$$

The optimization problem in (4) can be formulated as a constrained optimization problem,

$$\text{Minimize: } L = \frac{1}{2}\|\boldsymbol{\beta}\|^2 + \frac{1}{2}C\sum_{i=1}^{N}\|\boldsymbol{\varepsilon}_i\|^2$$

$$\text{Subject to: } \mathbf{g}(\mathbf{x}_i)\boldsymbol{\beta} = \mathbf{y}_i^T - \boldsymbol{\varepsilon}_i^T, i = 1,2,\dots,N \quad (7)$$

where $\boldsymbol{\varepsilon}_i$ is the ELM output error for i^{th} training data and C is a user specified parameter. By applying the Karush–Kuhn–Tucker (KKT) theorem [31] the solution of the optimization problem in (7) are as follow:

- If $N < n$, then

$$\boldsymbol{\beta} = \mathbf{G}^T\left(\frac{1}{C}\mathbf{I} + \mathbf{G}\mathbf{G}^T\right)^{-1}\mathbf{Y} \quad (8)$$

and the output of ELM is

$$\mathbf{f}(\mathbf{x}) = \mathbf{g}(\mathbf{x})\mathbf{G}\left(\frac{1}{C}\mathbf{I} + \mathbf{G}\mathbf{G}^T\right)^{-1}\mathbf{Y}. \quad (9)$$

- If $N > n$, then

$$\boldsymbol{\beta} = \left(\frac{1}{C}\mathbf{I} + \mathbf{G}^T\mathbf{G}\right)^{-1}\mathbf{G}^T\mathbf{Y} \quad (10)$$

and the output of ELM is

$$\mathbf{f}(\mathbf{x}) = \mathbf{g}(\mathbf{x})\left(\frac{1}{C}\mathbf{I} + \mathbf{G}^T\mathbf{G}\right)^{-1}\mathbf{G}^T\mathbf{Y}. \quad (11)$$

The predicted class label for an unknown data $\mathbf{x}_u$ is defined as the index of $\mathbf{f}(\mathbf{x}_u) = [f_1(\mathbf{x}_u), f_2(\mathbf{x}_u), \dots, f_k(\mathbf{x}_u)]^T$ that has highest value of $f_i(\mathbf{x}_u)$ for some $i \in [1,k]$. Therefore, the predicted class label for $\mathbf{x}_u$ can be determined using the following equation

$$class(\mathbf{x}_u) = \underset{i\in[1,k]}{\text{argmax}}\, f_i(\mathbf{x}_u). \quad (12)$$

A sigmoid function, as in (13), was employed as transfer function from the first layer to the second layer of ELM.

$$S(x) = \frac{1}{1+e^{-x}}. \quad (13)$$

Suppose $\mathbf{w}_i$ and $b_i, i = 12, \dots, n$ are the weight and bias, respectively, from the firs layer to i^{th} node in the second layer of ELM. In this study, $\mathbf{w}_i$ and $b_i, i = 12, \dots, n$ were randomly generated from normal standard distribution $\mathrm{N}(0,1)$. Therefore, the output of the second layer of ELM was

$$\mathbf{g}(\mathbf{x}) = [S(\mathbf{w}_1^T\mathbf{x} + b_1), S(\mathbf{w}_2^T\mathbf{x} + b_2), \dots, S(\mathbf{w}_n^T\mathbf{x} + b_n)]. \quad (14)$$

According to Huang, et al. [20] the classification performance of ELM depend on the value C and n. Therefore, this study employed grid search optimization to obtain the optimum values of C and n together with the optimum value of principle component. The values of C and n were chosen from the range $\{2^5, 2^{10}, 2^{15}, \dots, 2^{25}\}$ and $\{400, 410, 420, \dots, 1000\}$, respectively. The proposed method implemented ELM in Python language programing using scikit-learn 0.20.3 [30], NumPy 1.16.2 [32], and SciPy 1.2.1 [33] libraries.

C. Validation

Ubaya-IFDS3000 data set was divided into two disjoint subsets using stratified random sub sampling without replacement [34], with ratio 50:50 to validate the proposed method. The first subset was used as training data and the second as testing data. Five pairs of such subset were created to measure the accuracy of ELM.

ELM was trained using each training data with various parameter values for PCA and ELM provided by grid search optimization. The performance of the trained ELM was then measured by calculating the classification accuracy for the respective testing data using the following equation,

$$acc_i = \frac{Nc_i}{N_i} \times 100\% \quad (15)$$

where acc_i is the classification accuracy of ELM in the i^{th} testing data set, $i = 12, \dots, 5$, Nc_i and N_i are the number of correctly classified image and the number of image, respectively, in the i^{th} testing data set. The mean of classification accuracies was used to determine the optimal parameters for PCA and ELM and the performance of ELM.

III. Results and Discussion

The optimum parameters of PCA and ELM resulted from grid search optimization is tabulated in TABLE II. From TABLE II, it can be observed that the optimum parameter values varied between one combination of MPEG-7 descriptors and others. However, there were some combinations of MPEG-7 descriptors using same parameter values, such as $p = 0.89$ used in 10 combinations, $n = 940$ and $n = 1000$ used in five combinations, and $C = 2^5$ and $C = 2^{10}$ used in 10 and 14 combinations, respectively.

The classification accuracies of ELM using 24 combinations of MPEG-7 descriptors are summarized in TABLE III. The table also provide the summary of classification accuracies for k-NN and LDA reported [1]. From TABLE III, it can be seen that ELM achieved the best classification accuracy of 97.33%±0.33% by using C_9 as input features, followed by C_{10} (97.28%±0.34%) and C_{12}(97.23%±0.30%). From 24 combinations of descriptors, ELM achieved accuracy greater than 97% for 10 combinations, greater than 96% but less than 97% for 10 combinations, and between 94% and 96% for the rest. Furthermore, the classification accuracy of ELM had small standard deviation, between 0.14% and 0.60%. These results show that ELM achieves a good classification performance with small variation among different testing data set.

TABLE II. The Optimum Parameters of PCA and ELM

C_i	Optimum Parameters			C_i	Optimum Parameters		
	PCA	*ELM*			*PCA*	*ELM*	
	p	*n*	*C*		*p*	*N*	*C*
C_1	0.88	940	2^{10}	C_{13}	0.89	1000	2^{10}
C_2	0.99	930	2^5	C_{14}	0.89	920	2^{10}
C_3	0.89	940	2^{10}	C_{15}	0.89	1000	2^{10}
C_4	0.89	920	2^{10}	C_{16}	0.98	1000	2^5
C_5	0.92	870	2^5	C_{17}	0.97	960	2^5
C_6	0.89	940	2^{10}	C_{18}	0.98	970	2^5
C_7	0.98	1000	2^5	C_{19}	0.89	990	2^{10}
C_8	0.99	910	2^5	C_{20}	0.89	930	2^{10}
C_9	0.98	920	2^5	C_{21}	0.88	970	2^{10}
C_{10}	0.88	940	2^{10}	C_{22}	0.89	1000	2^{10}
C_{11}	0.88	970	2^{10}	C_{23}	0.98	980	2^5
C_{12}	0.89	940	2^{10}	C_{24}	0.91	960	2^5

TABLE III. Classification Performance Comparison of k-NN, LDA, and ELM using Some Combinations of MPEG-7 Descriptors

C_i	Accuracy (%)		
	k-NN [1]	*LDA* [1]	*ELM*
C_1	92.69 ± 0.52	92.83 ± 0.63	**97.04 ± 0.31**
C_2	96.09 ± 0.33	95.23 ± 0.49	**97.09 ± 0.23**
C_3	93.08 ± 0.47	95.96 ± 0.14	**97.21 ± 0.26**
C_4	92.83 ± 0.43	94.07 ± 0.42	**97.09 ± 0.26**
C_5	92.41 ± 0.87	92.96 ± 0.54	**96.37 ± 0.29**
C_6	92.73 ± 0.53	93.89 ± 0.84	**97.19 ± 0.14**
C_7	96.28 ± 0.37	96.13 ± 0.20	**96.95 ± 0.43**
C_8	94.55 ± 0.58	**94.92 ± 0.45**	94.83 ± 0.37
C_9	95.67 ± 0.47	96.05 ± 0.50	**97.33 ± 0.33**
C_{10}	93.39 ± 0.56	96.23 ± 0.23	**97.28 ± 0.34**
C_{11}	92.97 ± 0.44	95.57 ± 0.30	**96.73 ± 0.22**
C_{12}	93.17 ± 0.37	96.32 ± 0.41	**97.23 ± 0.30**
C_{13}	92.43 ± 0.88	93.79 ± 0.54	**96.51 ± 0.51**
C_{14}	92.84 ± 0.44	94.42 ± 0.36	**97.08 ± 0.19**
C_{15}	92.43 ± 0.50	93.87 ± 0.58	**96.57 ± 0.49**
C_{16}	94.65 ± 0.53	**95.61 ± 0.32**	95.00 ± 0.19
C_{17}	96.09 ± 0.67	96.57 ± 0.29	**96.89 ± 0.35**
C_{18}	94.44 ± 0.28	**95.65 ± 0.44**	95.15 ± 0.20
C_{19}	92.92 ± 0.59	95.96 ± 0.19	**96.71 ± 0.47**
C_{20}	93.28 ± 0.56	96.45 ± 0.46	**97.20 ± 0.42**
C_{21}	93.05 ± 0.45	95.97 ± 0.44	**96.73 ± 0.25**
C_{22}	92.44 ± 0.54	94.09 ± 0.69	**96.55 ± 0.60**
C_{23}	94.95 ± 0.44	**96.49 ± 0.32**	94.71 ± 0.51
C_{24}	92.92 ± 0.38	96.03 ± 0.46	**96.80 ± 0.55**

In comparison with *k*-NN and LDA, ELM achieved better classification performance compared to *k*-NN and LDA for almost all combination of MPEG-7 descriptors, as shown in TABLE III. However, the best performance of *k*-NN and LDA, which are 96.28% and 96.57%, resp., were still less than the best classification performance of ELM. This result show that ELM outperforms k-NN and LDA. From TABLE III, it can also be observed that more descriptors in the combination did not guarantee improve the performance of ELM. This phenomenon was also occurred in *k*-NN and LDA as reported in [1].

To increase the classification accuracy, study in [1] has proposed an ensemble of k-NN and LDA and obtained the best classification accuracy of 97.80±0.28%. The same approach was also performed in this study to increase the classification accuracy of ELM. Three ELMs which have highest classification accuracy were used as based classifier for the ensemble and obtained the classification accuracy of 98.03%±0.36%. This result show that the ensemble of ELM outperforms the ensemble of k-NN and LDA.

Furthermore, the performance of the combination descriptors used in this study was compared with statistical color features, color histogram and Unser's features. The segmentation process was performed to the fruit image before extracting the features. The classification accuracy of ELM with statistical color features, color histogram and Unser's features as input features together with the optimum parameters are shown in TABLE IV. From TABLE III and TABLE IV, it can be observed that the combination of MPEG-7 visual descriptors is more discriminative compared to statistical color features, color histogram and Unser's features when used as input features to ELM.

TABLE IV. CLASSIFICATION PERFORMANCE ELM USING STATISTICAL COLOR FEATURES, COLOR HISTOGRAM AND UNSER'S FEATURES

Features	Optimum Parameters			Accuracy (%)
	PCA	*ELM*		
	p	n	C	
Statistical color features	0.99	940	2^{15}	76.88 ± 0.86
Color histogram	0.99	670	2^{15}	80.05 ± 0.80
Unser's features	0.92	970	2^{10}	62.72 ± 1.19

The proposed method was implemented on a machine with processor Intel® Core™ i7-8550U and 20 GB RAM. The computational time needed to train the proposed classification method varied between 2.21 seconds to 2.69 seconds depending on the number of nodes in the second layer of ELM and the number of principle components used in PCA. Furthermore, the proposed method only needed about 67.8ms to classify a fruit image. However, grid search optimization required high computational time in determined optimum PCA and ELM parameters. On average grid search optimization took 7929 seconds to determine optimum parameter from 3960 possible values.

IV. CONCLUSION

This study proposed Indonesian fruits classification method from image. The method used constrained-optimization-based ELM as classifier and the combination of MPEG-7 visual descriptors. PCA was used to decrease the length of input features based on the proportion of the variation of original features that needs to be explained. The user specified parameters for PCA and ELM were optimized using grid search optimization such that the best classification performance is achieved. The proposed method has been evaluated using 3000 fruit images from Ubaya-IFDS3000 data set and obtained the best classification accuracy of 97.33%±0.33%. Furthermore, the experiment result also shows that ELM outperforms k-NN and LDA. For feature work, the using of other optimization method need to be considered to reduce the computational time in determining optimum PCA and ELM parameters.

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PROCEEDING

#3rd

ISRITI 2020

Yogyakarta - Indonesia

10 December 2020

ARTIFICIAL INTELLIGENCE for SOCIAL INTERACTIONS

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WELCOME SPEECH FROM THE CHAIRMAN OF STMIK AKAKOM YOGYAKARTA

The honourable
Keynote Speakers (Dr. Zoohan Gani from Victoria University and Assc. Prof. Ahmad Hoirul Basory from King Abdul Azis University)
Chairman of Widya Bakti Foundation and his staffs,
Representatives from IEEE Indonesia Chapter and Central IEEE,
Team of Indonesia Researcher and Scientist Institute,
Researchers and conference attendees,
Ladies and Gentlemen,

Assalamu'alaikum Wr. Wb.
May peace and health be upon us all.

First of all, let us express our utmost gratitude to God Almighty (SWT) for His blessings and grace so that even though in this coronavirus pandemic atmosphere, we can all still participate in the third iSriti international conference. On this occasion, let me express my sincere appreciation to the Keynote Speakers: Dr. Zoohan Gani from Victoria University, Sydney Australia, and Assoc. Prof. Dr. Ahmad Hoirul Basory from King Abdul Azis University, Rabig, Makkah, Saudi Arabia for their willingness to share their brilliant ideas and insights to be presented at this conference.

Dear ladies and gentlemen
On this occasion, as the head of STMIK AKAKOM Yogyakarta, I am saddened to state that the third iSriti conference had to be held online, considering that the coronavirus pandemic has not ended. Even though a pandemic currently hits us, the researchers' enthusiasm is apparent in the number of research articles submitted. We received up to 262 articles from 17 countries. Around 135 articles were accepted to be readily presented online in a conference forum with the theme: Artificial Intelligence for Social Interactions.
As the organizers of iSriti, we are very proud and grateful for the researchers' participation who have been willing to submit their research results to be published in this conference forum. We would also like to thank IEEE and IRSI, who have trusted and supported this conference from the very beginning. We still hope to build networks and information exchange between academics, practitioners, researchers, and the government to identify and explore issues, opportunities, and solutions to face challenges in the current era of technological disruption.

Finally, on this occasion, I would like to express my utmost gratitude to:
1) The distinguished keynote speakers who have been willing to share their valuable knowledge in this conference;
2) The third iSriti researchers who have presented and will present their research results;
3) Reviewers who have carefully reviewed the articles of the researchers;
4) Moderators who are more than willing to lead the plenary session;
5) IEEE for trusting us to hold this international conference;
6) IRSI, which has supported the third iSriti activities until now;
7) The committee that has been working hard to prepare this international conference according to plan;

Last but not least, as the organizer, I would like to sincerely apologize for any shortcomings or inconveniences during this event.

Thank you very much for your kind attention, and *Wassalamu'alaium Wr. Wb.*
Yogyakarta, 10 December 2020

The Chairman of STMIK AKAKOM Yogyakarta

Totok Suprawoto, M.M., M.T.

WELCOME SPEECH FROM
THE GENERAL CHAIR OF THE 3rd ISRITI 2020

Dear colleagues and friends.

On behalf of the organizing committee, I am delighted to welcome all participants to the 3rd International Seminar on Research of Information Technology and Intelligent Systems (ISRITI 2020). This conference is the third international conference held by STMIK Akakom Yogyakarta, Indonesia and the first to be held by STMIK Akakom in virtual form on December 10th, 2020.

In this conference, the committee decided to choose the following theme: “Artificial Intelligence for Social Interactions”. This highlight was chosen because various advances in the field of AI have recently raised concerns that AI will replace various things that are the human domain. For us, AI can be used to better understand social interactions and to build machines that work more collaboratively and effectively with humans. Therefore, by highlighting that theme in ISRITI 2020, we hope we can raise awareness towards AI for social interactions.

The aim of the conference is to provide an interactive international forum for sharing and exchanging information on the latest research in the area of information technology, computer sciences, informatics, and related fields. Nearly 135 academicians, researchers, practitioners, and presenters from 17 countries (Indonesia, Malaysia, India, USA, Brazil, Australia, South Korea, Hungary, Morocco, Vietnam, Iraq, China, Thailand, Turkey, Ireland, Romania, Russia, and Saudi Arabia) gathered in this event. In total, there are 262 active papers submitted to this conference. Each paper has been reviewed with tight criteria from our invited reviewers. Based on the review result, 135 papers have been accepted, which lead to an acceptance rate of 51.5%. This conference will not be successful without extensive effort from many parties. First, I would like to thank all keynote speakers for allocating their valuable time to share their knowledge with us. I would also like to express my sincere gratitude to all participants who participate in this conference. Special acknowledgement should go to the Technical Program Committee Chairs, Members, and Reviewers for their thorough and timely reviewing of the papers. We would also like to thank our sponsors: IEEE Indonesia Section and Research and Society Service Institution at STMIK Akakom. Last but not least, recognition should also go to the Local Organizing Committee members who have put enormous effort and support for this conference. At last, we hope that you have an enjoyable and inspiring moment during our conference. Thank you for your participation in ISRITI 2020.

Yogyakarta, 10 December 2020
General Chair of the 3rd ISRITI 2020

Dr. Bambang Purnomosidi D. P.

PREFACE

A language and reasoning can be said as some of the characteristics of human abilities. On the other hand, the ability of human thinking can be modeled as computation. The development of cognitive science that combines scientific development with technology began to appear in the 1960s. In those years, human behavior did not adequately explain cognitive processes. Although, there has been much debate by behaviorist experts regarding the cognitive science approach. However, with a variety of approaches, there is something quite encouraging that computer models of cognition can be used as an alternative approach to these various models. Furthermore, computers can be used to test hypotheses where computation itself is the subject of the mind. So that there are various kinds of models developed in the field of cognitive science with different fields of science, including anthropology, artificial intelligence (AI), philosophy, linguistics, neuroscience, and psychology. Even though there are different scientific fields, it turns out that they can work together in explaining various kinds of cognitive science models. AI is a part of the field of computer science that can describe intelligent computer systems. This system can show characteristics related to intelligence in human behavior, such as reasoning, understanding language, learning, solving problems, and so on. This intelligent system has a long-term goal of equaling or surpassing human intelligence. The approach used in simulating this system uses mathematical approaches, discursive reasoning, language, and so on. New developments related to the paradigm in this field emerged in the mid-80s, bringing together developments in the fields of philosophy, AI, and cognitive science.

Human intelligence is illustrated as a result of a program running on the human brain. In connectionist's view, information processing on computer devices is a fundamental difference from the brain. In the context-sensitive cognition model, human intelligence depends on the physical properties of the neurons. So that artificial intelligence requires brain-like computer skills, better known as neurocomputers. The purpose of this terminology is to design hardware compatible with neuro-computing. In this case, the model that is later known massively is an artificial neural network in which this model is trained, not programmed. Much information is extracted deeper than a representation that is presented in various forms that can be understood by humans. In the past, artificial emotions were somewhat neglected in AI and cognitive science. However, currently, emotional intelligence is one of the things that is raised with relevant information indicators in solving a case or problem. Emotion has an important domain in motivating and directing behavior. So that discussions in cognitive science and AI become one of the raw materials in representing information, then use it in social interactions. This representation is a language capable of thinking about problem-solving and social processes. This explains the systematics or methods used are very important in understanding cognition and communication in the context of social interaction. This pattern has appeared in the childhood phase in the learning process until later understanding their identity and interacting with others in the form of communication. The basis for this transformation is then essential in solving many cases in the world of science and technology.

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Fruits Classification from Image using MPEG-7 Visual Descriptors and Extreme Learning Machine(Conference Paper)

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Abstract

Fruit image classification has several applications and can be used as alternative to traditionally fruit classification performed by human expert. This paper aims to propose fruits classification method from image using extreme learning machine (ELM), MPEG-7 visual descriptors, and principle component analysis (PCA). The optimum parameters of ELM and PCA were determined using grid search optimization. The best classification performance of 97.33% has been achieved in classifying Indonesian fruit images consisted of 15 classes. By applying the ensemble of ELMs, the classification accuracy was increased to 98.03%. This result shows that the proposed method produces high classification performance. © 2020 IEEE.

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