Facial Biometric Identification in The Masked Face

by Dewi Yanti Liliana

Facial Biometric Identification in The Masked Face

Ardiansyah
Magister Ilmu Komputer
Universitas Nusa Mandiri
Jakarta, Indonesia
14002404@nusamandiri.ac.id

Dewi Yanti Liliana
Magister Ilmu Komputer
Universitas Nusa Mandiri
Jakarta, Indonesia
dewiyanti.liliana@tik.pnj.ac.id

2021 13th International Conference on Information & Communication Technology and System (ICTS) | 978-1-6654-4059-2/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICTS52701.2021.9607897

***Abstract*—The COVID-19 pandemic has brought challenges in the field of biometrics to be able to carry out biometric identification on masked faces. Various studies on biometric identification on masked faces have been carried out and some have obtained promising results. This study aims to obtain a biometric identification method for masked faces using the JAFFE database dataset which has been manipulated into masked face images. The proposed method in this study can produce an accuracy value of 96%, which is promising enough to be applied in the biometric industry. The proposed method uses the face area segmentation technique and extraction of local binary pattern and histogram of oriented gradient features with the Support Vector Machine classification method.**

Keywords*—*face recognition, local binary pattern, histogram of oriented gradient, support vector machine

I. Introduction

Face recognition is one of the most widely used biometric methods for personal identification, especially in the field of security such as access control. In addition, it is also widely used in attendance systems. Some of the advantages of the facial recognition system include that scanning can be done using a regular camera device that has been widely used and does not require direct contact between the object and the scanner device.

The COVID-19 pandemic has given rise to a strict health protocol so that everyone always avoids touching, maintains a distance, and always uses a mask [1]. The health protocol is a challenge for biometric systems that have been widely used. The facial recognition system is one of the methods that can fulfill the health protocol [2]. However, the masking protocol is a challenge for the facial recognition system because parts of the face are covered by the mask [3].

This study aims to obtain the most effective method in identifying individuals on a masked face in authentication and authorization systems where the environment is under control. The results of this study propose the use of a Support Vector Machine (SVM) classification algorithm with Local Binary Pattern (LBP) and Histogram of Oriented Gradient (HOG) features on partial facial images, namely the eye area and upper head. an accuracy value of 96% in the identification of individuals on masked faces. This shows that biometric recognition on masked faces is very possible and the proposed method can still be developed further.

This paper is organized into five parts, namely: The first part describes the background, objectives, and summary of the research conducted; The second part contains a literature review of previous studies; The third section will describe the design and implementation of the proposed method; The fourth part, research results, and discussion; The last part is the conclusion obtained from the results of the research that has been done.

II. Previous Works

Biometrics is a statistical measurement and test technique to represent a unique individual. This technique is widely used to locate and control access. One of the biological biometric methods is the face recognition method. Face recognition is closely related to the most obvious human identity, namely the face. The facial image-only procedure is very easy to do using a camera, even without the individual being identified. Several things that affect facial appearance include variations in posture, illumination, occlusion, and so on [4].

Various studies have been carried out to get the best facial recognition model. VenkateswarLal et. al., Ghazal et. al, Bindu et. al, and Liliana et. al, proposed the SVM classification algorithm in facial recognition methods to get the best performance in their respective studies [5]–[8]. Mulyono et al. al., Owais et. al., and Khan et. al. proposed the use of eigenfaces to reduce facial dimensional data and obtain the best data vectors to increase facial recognition accuracy and improve computational performance [9]–[11]. Ghorbani et. al, Nhat et. al, and Sun et. al, proposed a combination of LBP and HOG features in facial recognition methods [12]–[14].

Since the COVID-19 pandemic, various studies on methods of evaluating individuals on face masks have been carried out. Some of the research conducted is a response to the mandatory use of masks as an effort to prevent the spread of the COVID-19 virus.

Hariri researched facial recognition methods on face masks during the COVID-19 pandemic. The proposed method consists of 4 stages. First, do preprocess and cropping. Second, perform feature extraction using the VGG-16 model. Third, the deep bag of features layer method is used to compile the extracted features and create a global histogram with the RBF kernel. The last stage is conducting the classification training process using Multi-Layer Perceptron (MLP). The results of this study get a recognition rate of 91.3% [15].

Damer et. al. learn about the effect of wearing a mask on the performance of facial recognition algorithms. This research was conducted because of the widespread use of masks during the COVID-19 pandemic. The research was conducted on 3 types of face recognition, namely: ArcFace, SphereFace, and COTS. The results showed that the use of masks had a significant impact on the decline in the performance of the facial recognition algorithm, and the best performance was achieved by the COTS algorithm [16].

Ejaz et. al. researched masked face recognition using the Convolutional Neural Network (CNN). Furthermore, the FaceNet model is used in facial feature extraction and the SVM algorithm is used in the classification process. The research was conducted by making 8 scenarios for sharing training data and testing data. The results showed that the highest performance of 98.5% was obtained in scenario 2,

978-1-6654-4059-2/21/$31.00 ©2021 IEEE

where the training data contained a masked and unmasked face while the testing data contained a masked face [17].

Meanwhile, long before the COVID-19 pandemic occurred, in 2004, Savvides et. al. has researched robust and shift-invariant biometric approaches on partial facial images. The research was conducted by covering part of the face with several methods, either horizontally, vertically, or cropping. The results showed that the eye area had the highest recognition rate compared to other parts of the face [18].

III. Literature Study

SVM is a classification algorithm in machine learning that works by forming a separate hyperplane that linearly separates two different classes. Several strategies can be used in multiclass classification with SVM, namely one-to-one or one-to-many classification. SVM has proven to be a reliable classification algorithm and has been widely applied [8].

In several studies, the combined use of LBP and HOG features has been shown to complement each other and provide good performance in facial recognition [12], [14].

LBP is part of the Texture Spectrum model. LBP was first introduced by Ojala et. al. in their research on the comparative study of texture measurements in feature distribution-based classification [19]. The LBP operator will produce a binary value, where the binary value will be compared between the adjacent pixel values with the center value in an area measuring 3x3 which is called the neighboring area. The LBP pattern in a neighboring area with 8 adjacent pixels can be determined by the formula (1).

$$LBP(x,y) = \sum_{n=0}^{n-1} 2^n \times s(i_n - i_c) \quad (1)$$

where i_n is the pixel value at the coordinates of the neighboring area (x,y) and i_c is the pixel value at the coordinates (x,y). The operator will produce 2^n different outputs [20].

HOG is one of the descriptor features used to detect objects in computer vision. The technique used by HOG is to calculate the number of gradient orientations in an area with a local portion of an image. One of the advantages of HOG is that it is invariant to geometric and photometric transformations, except for rotation [21].

How the HOG method works in extracting objects consists of 4 stages [22]. First, calculate the gradation value by applying proper 1-D to obtain pseudo discrete derivative points in the horizontal and vertical directions by Formula (2) and Formula (3). Gradation level (|G|) and gradation orientation (θ) can be calculated by Formula (4) and Formula (5).

$$D_x = [-1 \quad 0 \quad 1] \quad (2)$$

$$D_y = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} \quad (3)$$

$$|G| = \sqrt{I_x^2 + I_y^2} \quad (4)$$

$$\theta = arctan \frac{I_y}{I_x} \quad (5)$$

The second step is to divide the spatial orientation as a bin. It serves to generate a histogram of cells through the voting process. In the third step, the normalization of cells and histograms from the entire block area is carried out using the HOG descriptor. The last step is the normalization of the block with the L2 norm formula as Formula (6).

$$b = \frac{b}{\sqrt{\|b\|^2 + \varepsilon^2}} \quad (6)$$

In this study, we will use the SVM classification algorithm with LBP and HOG feature extraction to see faces on masks.

Dlib is a C++ toolkit that has algorithms and machine learning functions including algorithms for detecting faces and algorithms for extracting feature points on faces. Dlib uses the Histogram of Gradients (HOG) and Support Vector Machine (SVM) features to detect faces and facial feature points. Dlib has provided a pre-trained model "shape_predictor_68_face_landmark.dat" to accurately detect 68 points of facial features [23].

OpenCV is a library developed by Intel for extracting and processing image data in computer vision [24]. Face recognition can be done quickly and reliably by using OpenCV [25].

IV. Research Methodology

This research will be carried out in several stages starting from the acquisition of facial image datasets, the pre-processing stage of facial images, the facial feature extraction stage, and the examination stage using a classification algorithm. These stages can be seen in Figure 1.

The dataset used in this study is the Japanese Female Facial Expression (JAFFE) database. The JAFFE dataset contains 213 images of 10 female models. The dataset was designed by Michael Lyons, Miyuki Kamachi, and Jiro Gyoba. The facial image data of each individual is then divided into 2 parts. Implementation of face recognition in authentication and authorization systems is usually done by taking several images of an individual's face in the registration process so that the system must be able to recognize the individual's face many times under various conditions. Therefore, in this study, the dataset is divided into 2 parts, namely training data and test data with the proportion of 20% training data and 80% test data. The distribution of data was carried out randomly and in a balanced manner so that the distribution of data was obtained as listed in Table I.

According to the scenario in this study, the model will be called with facial image data without a mask and tested to examine a masked face. Therefore, the face image in the test data covers some areas of the face so that it seems as if using a mask. Closing the face is done by adding a white polygon area from the bottom of the eye to the lower chin. The polygon field as an augmentation mask is created using the DLIB library which can have 68 points on the face. An example of partial closure of the facial area in the test data can be seen in Figure 2.

TABLE I. Data Class Distribution

No	Class (Subject)	Images	Train Data	Test Data
1	KA	23	7	16
2	KL	22	6	16
3	KM	22	7	15
4	KR	20	6	14
5	MK	21	6	15
6	NA	21	6	15
7	NM	20	6	14
8	TM	21	6	15
9	UY	21	6	15
10	YM	22	7	15
Total		**213**	**63**	**150**

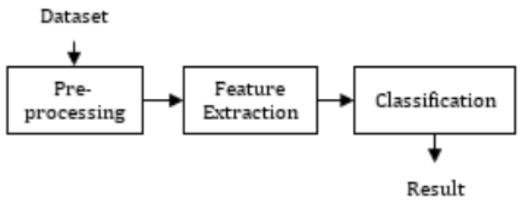

Fig. 1. Research Workflow

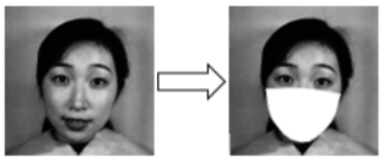

Fig. 2. Sample of Mask Augmentation

The next stage is pre-processing. At this stage, several things can be done on the image to get an image around the eye area that has uniform conditions and sizes as the region of interest (ROI). The stages carried out at this stage can be seen in Figure 3.

At this stage, the face image will be converted into a grayscale image, and histogram equalization is carried out to obtain a face image with uniform color and contrast levels. Furthermore, eye detection is performed on the ash image with the haar-cascade algorithm from the Open CV library. The algorithm produces two coordinates of the right eye point and the left eye point. Based on the coordinates of these points, the angle of the face in the image can be found using a trigonometric formula so that rotation can be carried out according to the tilt angle to obtain a face image with a horizontal position.

After obtaining a horizontal face image, cropping is done in the area around the eyes with the lower, right, and left borders being times the distance between the right eye and left eye, while the upper limit is the same as the distance between the right eye and left eye.

For the classification model to be carried out properly, the partial face image must have a uniform size. To get a uniform size, the face image is partially resized in width to 160 pixels with a height ratio, so that an image has a uniform width but still varies.

To get an image with a uniform height without changing the ratio size, a white image with a size of 160x160 pixels is created. Furthermore, the face image is superimposed on top of the white image so that a face image with a size of 160x160 pixels is obtained with white filling in the previously empty dimensions. We choose white as filled color because it is the common color of mask in this pandemic.

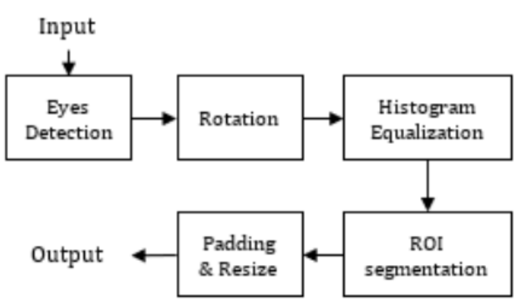

Fig. 3. Pre-processing Workflow

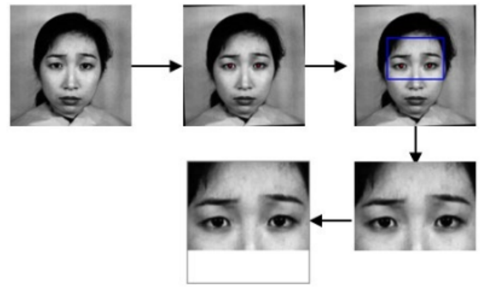

Fig. 4. Sample of Pre-processing

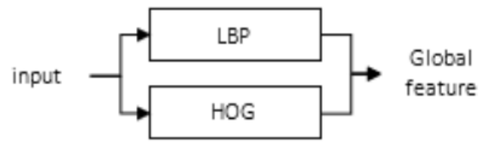

Fig. 5. Features Extractiom Workflow

The result of the pre-processing stage is a grayscale image measuring 160x160p pixels in the form of facial segments in the eye and forehead area with the right and left eyes aligned on a horizontal line and a uniform level of contrast. An example of an image at the pre-processing stage can be seen in Figure 4.

The next stage is feature extraction. At this stage, the LBP and HOG feature extraction is carried out on the facial segment image from the pre-processing results. The LBP feature extraction process will produce a vector with dimensions 14x1, while the HOG feature will produce a vector with dimensions 3200x1.

Furthermore, the two features are combined into a single vector called a global feature with dimensions 3214x1 to be used as input in the classification process. The stages of the feature extraction process can be seen in Figure 5, while an example of the visualization of the HOG and LBP feature extraction results can be seen in Figure 6.

The last stage in this research is the classification testing stage using the SVM classification algorithm with a liblinear kernel on the default parameter options without hyper-parameter optimization.

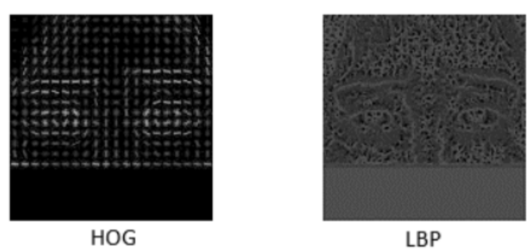

Fig. 6. Sample of HOG and LBP Image

TABLE II. PRE-PROCESSING PERFORMANCE

Class	Pre-processing					
	Train Data			Test Data		
	Input	Failed	Success	Input	Failed	Success
KA	7	1	6	16	1	15
KL	6	2	4	16	3	13
KM	7	0	7	15	3	12
KR	6	1	5	14	3	11
MK	6	2	4	15	4	11
NA	6	1	5	15	0	15
NM	6	2	4	14	0	14
TM	6	2	4	15	2	13
UY	6	0	6	15	0	15
YM	7	1	6	15	4	11
Total	**63**	**12**	**51**	**150**	**20**	**130**

V. RESULTS AND DISCUSSION

The results obtained in this study will be described per stage of the process. The first stage is dividing the dataset into training data and test data with a proportion of 30% training data and 70% test data to produce 63 training data images and 150 test data images. At this stage, the DLIB library succeeded in detecting facial points in all test data images so that 150 face images with masks were obtained in the test data.

In the pre-processing stage, eye detection is carried out using haar-cascade to determine the desired region. The haar-cascade algorithm failed to detect eye points in 12 face images in the training data and 20 face images in the test data, so that the data that can be performed feature extraction are 51 training data images and 130 test data images as can be seen in Table II. Thus the success rate of haar-cascade in detecting eye points is 81% on training data and 86% on test data.

These results indicate that haar-cascade has a weakness in detecting eyespots. The ability to detect faces is a major problem in face masks because the face is the main face that can be done on the face.

At the feature extraction stage, all pre-processed image results, both training data, and test data were successfully extracted with the number of feature elements each numbering 3.214 feature elements which are a combination of LBP, and HOG features.

At the classification stage using SVM, the accuracy of the proposed method reaches 96%. Of the 10 data classes, 6 classes get a perfect F1 score, 3 classes get a score above 90% and only 1 class gets a score of less than 90%. The average F1-score also reached 96% for both Macro AVG and Weighted AVG, indicating that the dataset used in this study has a good balance. the test results are obtained as can be seen in Table III

TABLE III. CLASSIFICATION REPORT

Subject	Precision	Recall	F1-score	Support
KA	0.79	1.00	0.88	15
KL	1.00	0.85	0.92	13
KM	1.00	1.00	1.00	12
KR	1.00	1.00	1.00	11
MK	1.00	1.00	1.00	11
NA	1.00	1.00	1.00	15
NM	1.00	1.00	1.00	14
TM	1.00	0.85	0.92	13
UY	1.00	1.00	1.00	15
YM	0.91	0.91	0.91	11
Accuracy			**0.96**	**130**
Macro AVG	0.97	0.96	0.96	130
Weighted AVG	0.97	0.96	0.96	130

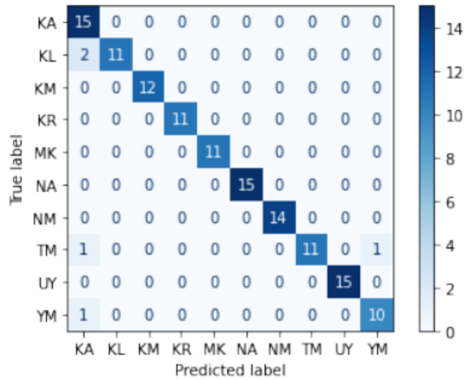

Fig. 7. Confusion Matrix

When viewed from the amount of data support in each class, there are 5 categories of total data, namely 11,12, 13, 14, and 15. Classes that get an F1-score of less than 100% are spread over several categories of data amounts, namely 11, 13, and 15. This shows that the test data has a uniform quality with a balanced distribution of the amount of data.

The classification performance in this study can be seen in the confusion matrix in Figure 7.

The confusion matrix shows that 2 data classes get False Positive, namely the KA class and the YM class. The KA class has the most False Positive (FP) values, which is 4, while the YM class gets a value of 1. 3 data classes get False Negative (FN) values, namely KL gets 2 FN, TM gets 1 FN, and YM gets 1 FN.

VI. CONCLUSIONS

Biometric identification on a masked face is a challenge in the field of biometrics, especially during the current COVID-19 pandemic. This study tried to conduct biometric experiments on masked faces with the JAFFE database dataset that was manipulated with a layer mask and was able to produce an accuracy value of up to 96%. This is a promising result for implementing the proposed model in the field of biometrics.

The weakness of face detection in masked faces can be a challenging topic for future research. In addition, the model in this study uses the SVM classification algorithm which is a traditional classification, so it can be done to continue the application of the CNN method in facial research on masked faces.

REFERENCES

[1] World Health Organization (WHO), "Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19): Interim guidance, 6 April 2020," *Who*, vol. 2019, no. 6 April, pp. 1–7, 2020.

[2] R. Jaiswal, A. Agarwal, and R. Negi, "Smart solution for reducing the COVID-19 risk using smart city technology," *IET Smart Cities*, vol. 2, no. 2, pp. 82–88, 2020.

[3] I. Q. Mundial, M. S. Ul Hassan, M. I. Tiwana, W. S. Qureshi, and E. Alanazi, "Towards Facial Recognition Problem in COVID-19 Pandemic," pp. 210–214, 2020.

[4] M. Sharif, M. Raza, J. H. Shah, M. Yasmin, and S. L. Fernandes, "An overview of biometrics methods," *Handb. Multimed. Inf. Secur. Tech.*

Appl., pp. 15–35, 2019.
[5] P. VenkateswarLal, G. R. Nitta, and A. Prasad, "Ensemble of texture and shape descriptors using support vector machine classification for face recognition," *J. Ambient Intell. Humaniz. Comput.*, vol. 0, no. 0, p. 0, 2019.
[6] M. T. Ghazal and K. Abdullah, "Face recognition based on curvelets, invariant moments features and SVM," *Telkomnika (Telecommunication Comput. Electron. Control.*, vol. 18, no. 2, pp. 733–739, 2020.
[7] C. H. Bindu and K. Manjunathachari, "Kernel-based scale-invariant feature transform and spherical SVM classifier for face recognition," *J. Eng. Res.*, vol. 7, no. 3, pp. 142–160, 2019.
[8] D. Y. Liliana and I. M. Agus Setiawan, "Face Recognition with Kernel Principal Component Analysis and Support Vector Machine," *Proc. - 1st Int. Conf. Informatics, Multimedia, Cyber Inf. Syst. ICIMCIS 2019*, pp. 175–180, 2019.
[9] I. U. Wahyu Mulyono, D. R. Ignatius Moses Setiadi, A. Susanto, E. H. Rachmawanto, A. Fahmi, and Muljono, "Performance Analysis of Face Recognition using Eigenface Approach," *Proc. - 2019 Int. Semin. Appl. Technol. Inf. Commun. Ind. 4.0 Retrosp. Prospect. Challenges, iSemantic 2019*, pp. 12–16, 2019.
[10] M. Owais, A. Shaikh, A. A. Jalal, and M. M. Hassan, "Human Face Recognition using PCA Eigenfaces," *ICETAS 2019 - 2019 6th IEEE Int. Conf. Eng. Technol. Appl. Sci.*, 2019.
[11] M. S. Khan, A. Ware, and A. Khan, "Face Acknowledgment using Principle Component Analysis (PCA) of Eigenfaces," *Int. J. Innov. Technol. Explor. Eng.*, vol. 9, no. 7, pp. 1196–1200, 2020.
[12] M. Ghorbani, A. T. Targhi, and M. M. Dehshibi, "HOG and LBP: Towards a robust face recognition system," *10th Int. Conf. Digit. Inf. Manag. ICDIM 2015*, no. Icdim, pp. 138–141, 2016.
[13] H. T. M. Nhat and V. T. Hoang, "Feature fusion by using LBP, HOG, GIST descriptors and Canonical Correlation Analysis for face recognition," *2019 26th Int. Conf. Telecommun. ICT 2019*, pp. 371–375, 2019.
[14] M. Sun and D. Li, " Smart face identification via improved LBP and HOG features ," *Internet Technol. Lett.*, no. July, pp. 1–6, 2020.
[15] W. Hariri, "Efficient Masked Face Recognition Method during the COVID-19 Pandemic," no. July, 2020.
[16] N. Damer, J. H. Grebe, C. Chen, F. Boutros, F. Kirchbuchner, and A. Kuijper, "The effect of wearing a mask on face recognition performance: an exploratory study," *arXiv*, 2020.
[17] M. S. Ejaz and M. R. Islam, "Masked face recognition using convolutional neural network," *2019 Int. Conf. Sustain. Technol. Ind. 4.0, STI 2019*, vol. 0, pp. 1–6, 2019.
[18] M. Savvides, B. V. K. Vijaya Kumar, and P. K. Khosla, "Robust, Shift-invariant Biometric Identification from Partial Face Images," *Biometric Technol. Hum. Identif.*, vol. 5404, pp. 124–135, 2004.
[19] T. Ojala, M. Pietikäinen, and D. Harwood, "A comparative study of texture measures with classification based on feature distributions," *Pattern Recognit.*, vol. 29, no. 1, pp. 51–59, 1996.
[20] Y. Yang, B. Vuksanovic, and H. Ma, "Effects of region features on the accuracy of cross-database facial expression recognition," *ICAART 2020 - Proc. 12th Int. Conf. Agents Artif. Intell.*, vol. 2, no. Icaart, pp. 610–617, 2020.
[21] U. Mlakar and B. Potočnik, "Automated facial expression recognition based on histograms of oriented gradient feature vector differences," *Signal, Image Video Process.*, vol. 9, pp. 245–253, 2015.
[22] M. M. Isaac and M. Wilscy, "A key point based copy-move forgery detection using HOG features," *Proc. IEEE Int. Conf. Circuit, Power Comput. Technol. ICCPCT 2016*, 2016.
[23] D. E. King, "Dlib-ml: A machine learning toolkit," *J. Mach. Learn. Res.*, vol. 10, pp. 1755–1758, 2009.
[24] G. Bradski, "The OpenCV Library," *Dr. Dobb's J. Softw. Tools*, 2000.
[25] M. Khan, S. Chakraborty, R. Astya, and S. Khepra, "Face Detection and Recognition Using OpenCV," in *2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS) Face*, 2019, pp. 116–119.

Facial Biometric Identification in The Masked Face

ORIGINALITY REPORT

6%	4%	6%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

1%

★ Submitted to Universitas Indonesia

Student Paper

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		