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QUALITY ANALYSIS AND ILLEGAL LOGGING IMAGE DETECTION USING SYARITAR METHOD

Syafruddin Syarif[1], Syafaruddin[1], Wardi[1] and Shinya Kobayashi[2]

[1]Department of Electrical Engineering
Universitas Hasanuddin
Tamalanrea, Makassar 90245, Indonesia
syafruddin.s@eng.unhas.ac.id; {syafaruddin; wardi}@unhas.ac.id

[2]Graduate School of Science and Engineering
Ehime University
Bunkyou-cho, Matsuyama, Ehime 790-8577, Japan
kob@cs.ehime-u.ac.jp

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Abstract. *The activity of illegal logging causes great losses related to economy, ecology and loss of natural balance due to the disruption of the natural functions of forests. Therefore, the establishment of logging detection systems is useful for assisting government policy, especially in the forest preservation program based on remote sensing technology. In this study, the detection of illegal logging is developed by using Discrete Cosine Transform-Hidden Markov Model (DCT-HMM), which is called Syaritar method in this paper. In this method, the stages of image processing systems utilize the selection index of which values are taken from an RGB image that is previously being extracted from the DCT-HMM process. The data samples for testing image are taken from protected forest areas in Sumatera (Lahat region) Indonesia with the size of* $84 \times 84 m^2$ *considering image data pairs in 2006, 2007 and 2009 as initial and final data, respectively. The identification results provide the level of accuracy in illegal logging detection activity of 77.76%.*
Keywords: Quality analysis, Image detection, Illegal logging, Syaritar method

1. **Introduction.** It is well known and impossible to deny that forest or forestry has benefited humankind in supporting human livings. As a buffer ecosystem and lung of the world, forests provide an invaluable benefit for clean air circulation environment. In terms of domestic economy, the forestry sector contributes significantly in national income accounts. Until the early 90's, high prices in international markets have led timber exploitation on a large scale with exports to earn foreign orientation [1,2]. The last factor much less motivates local people to cut off the forest in uncontrollable manners.

Illegal logging is tree-felling activity without control and permission from government or forest authority. Illegal logging gives significant impact both economically and ecologically. From economic sectors point of view, the loss of income results from the reduction in the State's taxes on the wood value. In a broader scale, it means the lost opportunity to capitalize on the product diversity in the future. In addition, the larger actual loss, which cannot be assessed, is the loss obtained due to the disruption of forest. On the other hand, the environment impact of illegal logging is the loss of the natural balance that may affect global climate change, decline land productivity, and cause soil erosion, floods, and habitat destruction including loss of biodiversity.

For these reasons, the establishment of logging detection systems is useful for assisting government policy, especially in the forest preservation program based on remote sensing technology. Nowadays, image-processing technology enters wide application in various

fields, for instances, biomedicine, astronomy, archeology, archival images and document, industry, and remote sensing. In terms of remote sensing based illegal logging detection systems, the method is highly supported by the availability of digital images for most parts of the Earth's surface. In this research, the data images are obtained from Google Earth application. Google Earth application has capability of composing high-resolution images (Quick bird, Iconos, Geo-eye) and medium resolution imagery (Landsat, Aster, Spot).

Another method in image identification system is based on DCT (Discrete Cosine Transform). A mathematical transformation takes and converts the signal from spatial domain into the frequency domain. Many digital images and video compression schemes use block-based DCT due to its algorithm is able to minimize the amount of data needed to create digital images. In particular, JPEG and MPEG use DCT technique to concentrate image information by removing the spatial redundancy in the two-dimensional image. In the DCT, transformation is also known as low-, medium-, and high frequency terms. According to this, it relates to the frequency of the wave of DCT basis functions. In terms of the function of a small base, the corresponding coefficients are called low-frequency coefficients, and so on. However, the DCT method can detect the illegal logging at the minimum area only $2m^2$ for each pixel [2]. This paper proposes Syaritar method to increase the quality of coverage area per pixel in image detection. The method of quality analysis and image illegal logging detection is explained as follows.

2. Syaritar Method.

The detection system of illegal logging is developed into three stages. The first stage is the processing stage. This stage is to capture images and determine which images will be used. This stage also decides parameters of illegal logging based on the images. The second stage is creating the Syaritar method. The method to detect the illegal logging is made and trained with the data obtained from previous stage. The last stage is testing the system. This stage aims to assess the accuracy of the Syaritar method in detecting illegal logging. Syaritar method is a hybrid of DCT and HMM.

2.1. DCT (Discrete Cosine Transform).

DCT converts a signal into its fundamental components. DCT was first introduced on image processing and a discrete cosine transform [4,6].

DCT has two main properties for image and video compression, namely [2]:

1) Concentrating image energy into a small number of coefficients (energy compaction).
2) Minimizing the mutual dependence between the coefficients (correlated).

Constant factor was chosen such as the orthogonal and normalized basis vector. DCT can also be obtained from the vector product (input) and $(n \times n)$ orthogonal matrix in which each row is a basis vector. The eight basis vectors $n = 8$, and each basis vector corresponds to a particular frequency sinusoid curve [3,5].

The process of designing this system is done by a DCT function of Matlab. Data image is processed to the gray scale image before processing in DCT method. Data from the clustering index has been created and put into the function of DCT as a parameter to determine the level of illegal logging.

2.2. HMM (Hidden Markov Model).

Markov chains are useful for calculating the probability of the sequence of the state that can be observed. Sometimes there is a sequence from a state that cannot be observed. In this case, a new model is developed that can model the state of hidden state. HMM state cannot be directly seen even though the model parameters are known. The process is hidden but the output dependent on the state can be seen [7,8]. The training process of Gaussian Mixture Model (GMM) and Hidden Markov Model (HMM) is shown in Figure 1.

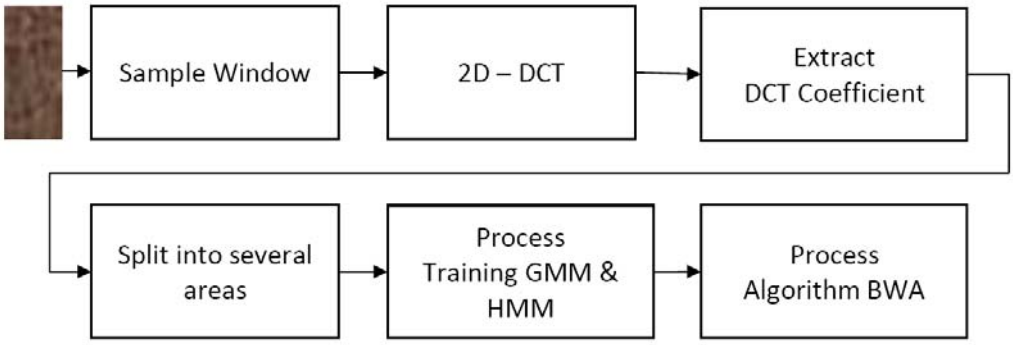


FIGURE 1. GMM and HMM training process

Gaussian Mixture Model (GMM), with the master estimating a distribution of good solutions in the search space as a set of cluster, assumes that good solutions in each cluster follow a Gaussian distribution [10].

3. **Proposed System.**

3.1. **System design and creation.** This method is a hybrid of the DCT and HMM. The DCT coefficient sets to generate each RGB value that contains most of the information from the existing color of the frequency on the graph. To know the accuracy of the method used, the testing is done manually by entering the system value of the threshold program of the list with a system of trial and error.

The output of the testing phase system is done by inserting a tested image. Then, it is analyzed to determine those areas experiencing illegal logging. The steps can be seen in Figure 2.

Forward-Backward algorithm is used in program application to search the same parameters. The algorithm scans each pixel from left to right to find identical characteristics with existing image. If a match with parameters, the program will mark the area and continue the search process to the next pixel. The process will continue into the pixel underneath and then search from left to right. Once the process ends, the output will show the image to indicate that the area experiences illegal logging [9].

3.1.1. *Groove and system architecture.* There are two main parts in the detection of illegal logging system design: extraction stage and characteristic saving, and matching process using DCT method. Extraction results will be saved into a file while the gray scale image data is normalized until the image reaches the size of 200×200 pixels. The image loading process feature operates matching stage.

Furthermore, the index extraction value is matched by using the DCT method as an illegal logging detector.

3.1.2. *Decision making and the input image design system.* Image captured for data input through cropping and normalization with the size 530×400 pixels is classified by the index value of each pixel to the forest and trees cutting based on the level of damage. The value of the index image on any areas that experiences illegal logging, is based on the level of damage to forests which, can be classified into three types of illegal logging. (1) The value of ≤ 150 index is categorized as low illegal logging. (2) The value index from 150 to 200 is categorized as medium illegal logging. (3) The value index of ≥ 200 is categorized as severe illegal logging.

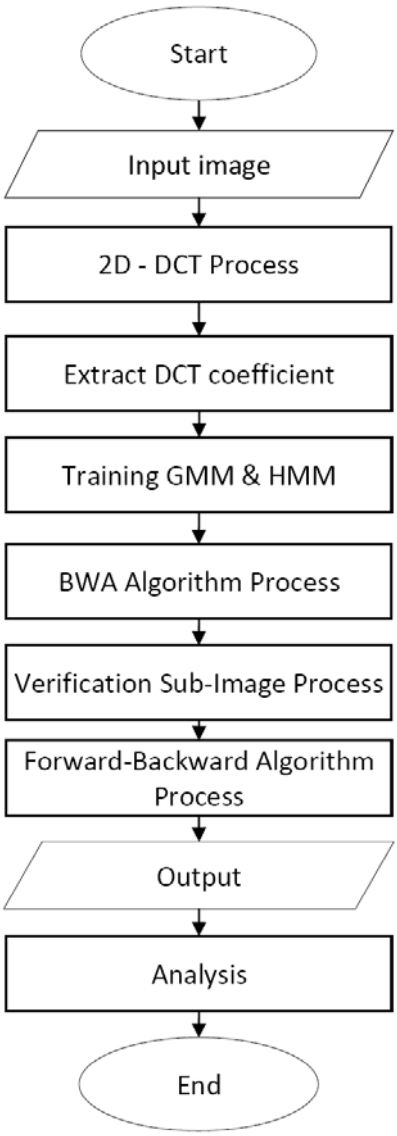


FIGURE 2. Flowchart of testing systems

The process of designing this system is done by a DCT function of Matlab. Data from the clustering index has been created and put into the function of DCT as a parameter to determine the level of illegal logging.

3.2. **Description of testing system.** The results of detection by Discrete Cosine Transform can be determined by administering color map (jet) in the output image. The difference among the data area cut at the end of the area felling on preliminary data, will yield a value, i.e., (1) the reduction of value is positive (+) or > 0 then illegal logging; (2) the reduction of value negative (−) is not the case of illegal logging.

To find the area of illegal logging, the calculation of forest area in the image is firstly performed. The calculation of coverage area per pixel in the image is:

$$\text{Cell area per pixel} = \frac{\text{Wide region image } (\text{m}^2)}{\text{Quantity of image (pixel)}}$$

The area of illegal logging is 0.18m^2 per pixel.

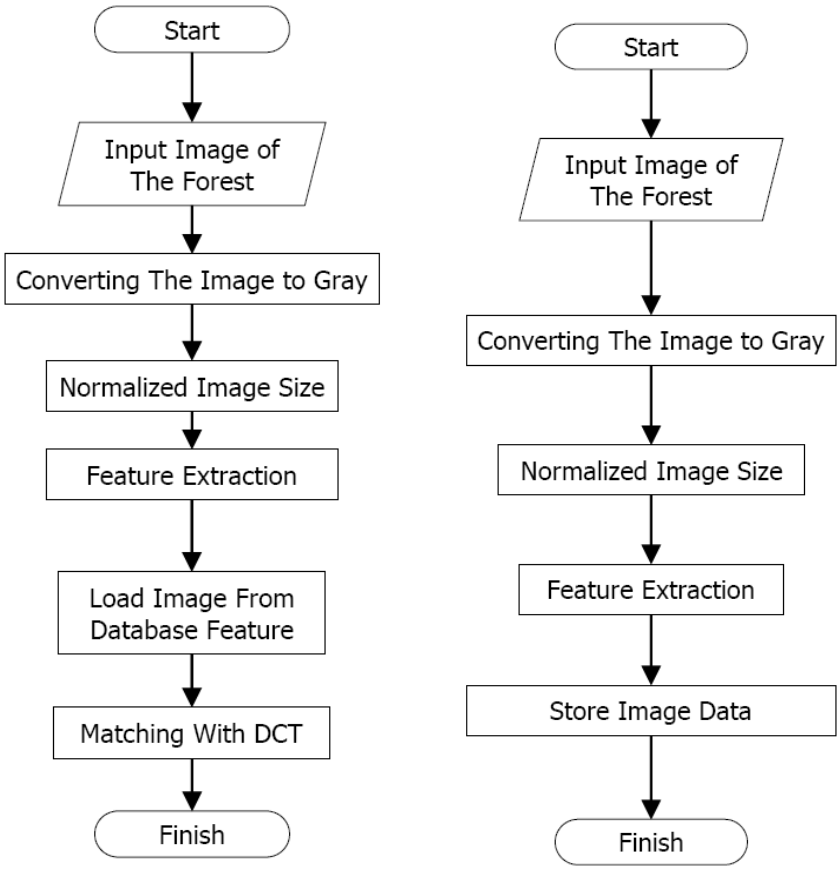
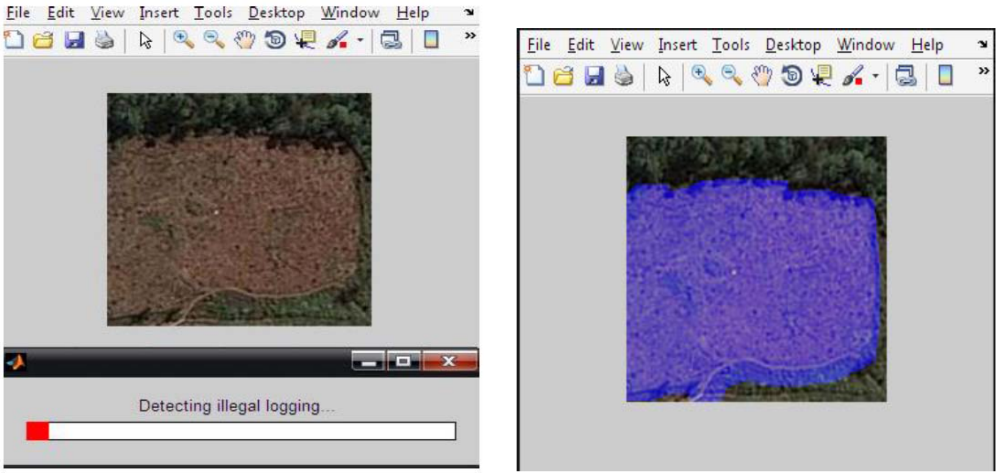


FIGURE 3. Flowchart of feature extraction and storage

This research performed a system testing phase to see the ability of the DCT-HMM method. The stage begins by inserting the images into a system that has been created. The system combines the DCT and HMM methods. DCT method is used to produce a set of coefficients for each value of RGB (Red, Green and Blue) in which each color contains most of the information about the frequency of the existing color on the images. While the HMM method is used for calculating the probability of the sequence of the hidden state. The output of the system is then analyzed to determine whether the areas experienced illegal logging or not.

To know the accuracy of the method, the testing system was conducted by inputting manually the threshold values in listing program. Each image has a threshold value that varies depending on the characteristics of the image. Threshold values that are too large or too small will reduce the quality of its output. Therefore, it must find proper threshold values for each input image by doing trial and error.

4. **Results and Discussions.** This research discusses about designing of a system for detecting illegal logging using the Discrete Cosine Transform and Hidden Markov Model, which is called Syaritar method. Sample images from satellite images of Lahat region (in Sumatera, Indonesia) converted to gray scale prior to process in the Syaritar method. Then, Syaritar method will detect the illegal logging. Testing system is done by sampling the index of the areas with trees and without trees.



(a) Before matching process (b) After matching process

FIGURE 4. The example of the results

TABLE 1. The detection results of Syaritar method

Data	Year	Area Illegal Logging (m^2)	Result	Validation
Sum 1	2006	883.26	Illegal Logging detected	ILLEGAL LOGGING
	2007	–	Non Illegal Logging	NON ILLEGAL LOGGING
	2009	1740.42	Illegal Logging detected	ILLEGAL LOGGING
Sum 2	2006	–	Non Illegal Logging	NON ILLEGAL LOGGING
	2007	3169.44	Illegal Logging detected	ILLEGAL LOGGING
	2009	3331.26	Illegal Logging detected	ILLEGAL LOGGING
Sum 3	2006	1856.34	Illegal Logging detected	ILLEGAL LOGGING
	2007	1450.26	Illegal Logging detected	ILLEGAL LOGGING
	2009	2449.44	Illegal Logging detected	ILLEGAL LOGGING

The system will provide a blue mark on the detected image having logging as shown in Figure 4(b). Furthermore, calculations are performed for the first image and the second image. The difference between the areas in the second image data to the area in the first image data will specify whether the area is experiencing illegal logging (value > 0) or non-illegal logging (value ≤ 0). The results can be seen in Table 1 and Table 2.

Figure 4 describes a forest image without using Syaritar function and a forest image using Syaritar function. Based on the identification above, the DCT-HMM method can identify the illegal logging with a satisfactory level of accuracy 77.76%. These results cannot be maximized, as the DCT-HMM is less able to distinguish areas with woodlands felled tree at high brightness levels. Detection of illegal logging in the system can detect minimal logging with a $0.18m^2$ area, because the scale used for one pixel in the image equals $0.18m^2$ on the true scale.

5. **Conclusion.** The early identification of the presence or absence in illegal logging activity can be determined from the difference in the final data of felled tree area and preliminary data. The increase of felled tree area in final data assessment indicates the high intensity of illegal logging activity. Discrete Cosine Transform-Hidden Markov Model method can be used to identify the illegal logging with the accuracy level 77.76%. These results cannot be maximized, as the DCT-HMM is less able to distinguish areas with

TABLE 2. The detection results of DCT method

Data	Year	Area Illegal Logging (m^2)	Result	Validation
Sum 1	2006	588	Illegal Logging detected	ILLEGAL LOGGING
	2007	–	Non Illegal Logging	NON ILLEGAL LOGGING
	2009	56	Illegal Logging detected	ILLEGAL LOGGING
Sum 2	2006	–	Non Illegal Logging	NON ILLEGAL LOGGING
	2007	–	Non Illegal Logging	ILLEGAL LOGGING
	2009	1608	Illegal Logging detected	ILLEGAL LOGGING
Sum 3	2006	–	Non Illegal Logging	NON ILLEGAL LOGGING
	2007	40	Illegal Logging detected	ILLEGAL LOGGING
	2009	–	Non Illegal Logging	ILLEGAL LOGGING

woodlands felled tree at high brightness levels. Detection of illegal logging in the system can detect minimal logging with a $0.18m^2$ area, because the scale used for one pixel in the image equals $0.18m^2$ on the true scale. Nevertheless, the proposed method of Syaritar may be determined by the lighting level and quality of the properly input image.

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