Natural Disaster Detection Using Wavelet and Artificial Neural Network

Albertus Joko Santoso
Informatics Engineering
University of Atma Jaya Yogyakarta
Jl. Babarsari 43, Yogyakarta 55281, Indonesia
albjoko@staff.uajy.ac.id

Findra Kartika Sari Dewi
Informatics Engineering
University of Atma Jaya Yogyakarta
Jl. Babarsari 43, Yogyakarta 55281, Indonesia
findra@staff.uajy.ac.id

Thomas Adi Purnomo Sidhi
Informatics Engineering
University of Atma Jaya Yogyakart
Jl. Babarsari 43, Yogyakarta 55281, Indonesia
th.adi.ps@staff.uajy.ac.id

***Abstract*—Indonesia, by the location of its geographic and geologic, it have more potential encounters for natural disasters. This nation is traversed by three tectonic plates, namely: Indo-Australian, the Eurasian and the Pacific plates. One of the tools employed to detect danger and send an early disaster warning is sensor device for ocean waves, but it has drawbacks related to the very limited time gap between information/warnings obtained and the real disaster event, which is only less than 30 minutes. Natural disaster early detection information system is essential to prevent potential danger. The system can make use of the pattern recognition of satellite imagery sequences that take place before and during the natural disaster. This study is conducted to determine the right wavelet to compress the satellite image sequences and to perform the pattern recognition process of a natural disaster employing an artificial neural network. This study makes use of satellite imagery sequences of tornadoes and hurricanes.**

Keywords—component; disaster detection; pattern recognition; Wavelet; Artificial Neural Network

I. INTRODUCTION

One of the common problemsfaced by image processing usersis the size ofmemory. Pictures can say thousands of words, but their size also take space to store. When a picture is distributed on thetransmission the bandwith needed isas big as the size of the image file. This brings consequences to telecomunication technology that is to compress image to save bandwith, time to distribute the image and lower the memory cost.

Patern recognition isone amethodto detect a disaster of many ways attempting to minimize disaster casulties. This research is an attempt to reach this goal. Through a pattern recognition taken fromsatellite image sequence and by performing anartificial neural network, we try to give a more acurate prediction and faster image processing in order to minimize the casulties cause by disaster.

Geographically and geologically, Indonesia potentially encountersvarious natural disasters. Efforts to prevent or detect natural disasters are developed continuesly in order to produce fast and accurate early predictions. One of the efforts that hasbeen done is the installation of a sensor which can detect the changes of ocean waves.The sensoris placed in the middle of the ocean. However, the sensor has some weaknesses, such as the time gapbetween the information obtained andthe occurrence of natural disasters is very short, probably less than 30 minutes. Hence, there is a need to innovate a detector which can provide information at least 24 hours in advance, so that people can evacuate themselves long before a natural disaster occurs.

II. LITERATURE REVIEW

A. Image Compression Using Wavelet

Computers that being used in efforts to achieve required resolution for multimedia applications or large image databases always have limitation.This is due to the increasing quality of digital images that also increase the size of an image.To overcome this problem, compression process is became more needed [6].

Good quality image mean larger size, therefore it need more memory. However, most images contain duplicate data that can be seen in the colour combination, and also where a pixel has the same intensity with neighboring pixels, so somepixel waste storage space. An image contains a lot of the same parts (regions), so redundancy can be seen in these same sections that do not need to be coded repeatedly as it creates waste. Image compression can only reduces the redundancy of the image data stored or transmitted, and then the image can be reconstructed in accordance with human visual perception [9].

There is technique for image data compression that using wavelet transformation. In this compression method, the wavelet transformation get advantages when it detects a very small difference between the original image and the reconstruction image, even after quantization process.The non-negative threshold value will make the image elements with a very small value to be zeroed, so it can produce a very sparse matrix [8].This sparse matrix is useful for stored and transmitted the image data, in addition to the results of the reconstruction that have a very small value of MSE or as good as the original image when visually seen.

Nowadays, wavelet applications and ressearch are get much attention in research topic; one of them is for image analysis. In example, wavelet decomposes the original signal into signals in several frequencies (called multi-resolution analysis), and an analysis can be performed by Discrete Wavelet Transform [5] or the standard decomposition techniques and the non-standard with Haar wavelet [2]. Image

signature generated by wavelet is taken from wavelet coefficient at a certain level (e.g. 3, 4 or 5) and can be resized into much smaller than the original one.

B. Artificial Neural Network

Artificial Neural Network (ANN) is an example method that use a network of a small processing unit group modeled based on human neural network. ANN is a system that can be adaptive, to solve problems it can change its structure based on external or internal information from the network. It can be simply said that, ANN is a non-linear statistical modeling tool. In other case for finding patterns in the data, ANN can be used to model complex relationships between inputs and outputs. ANN concept are originated on the paper of McCulloch and Pitts (1943), this paper attempts to formulate a mathematical model of brain cells.

According to Haykin [4], a neural network is a parallel-distributed processor. This method tendency are to keep knowledge acquired from the experience and keep it available. It resembles the brain works in two ways: 1. Knowledge acquired through a learning process. 2. Strength of the relationship between nerve cells, or known as synaptic weights, this is also being used to store knowledge.

This method are good to be used in many case of patern recognition. ANN ability are being used in many case to solved patern recognition problem.

C. Pattern Recognition

Pattern is an entity that is defined and can be identified and given a name by its features. Pattern recognition can be defined as "the act of taking raw data and act on data classification" [3][7]. Pattern recognition aims to determine the groups or categories of pattern based on the characteristics owned by the pattern. A pattern recognition system acquires data over a sensing device or sensor, sets the form of data representation, as well as makes the process of analysis and classification of data. Data can be formed as image or a one-dimensional signal based on changes in time.

There are two stages and objectives of apattern recognition process, i.e. [1]: (1) Putting pattern into an unknown class of patterns known as clustering or unguided classification. (2) Identify patterns as a member of a class that is already known. The process is called supervised classification.

The early use of pattern recognition is to recognise the characteristics and classification of white blood cells. But after a few years, pattern recognition methods have been applied to a number of ,very small object forms such as bacteria, viruses, and cells. Moreover, pattern recognition technique is also used for satellite data processing to produce information about the condition of the soil, plant varieties, weather patterns, and the Earth's surface topography.

III. Research Methods

D. Research Materials

Test images used as research materials are in the form of a satellite imagery sequence. While satellite still imagesare displayed in sequence, they give the impression to the eyes as a moving image. The test images used for this study are two types of movement sequences of satellite imagery, one is of atornado and one of a storm, which were then tested with Haar, Coiflet1, Coiflet3, Symlet2, Symlet5, 1AJS, AJS2, andAJS 3.

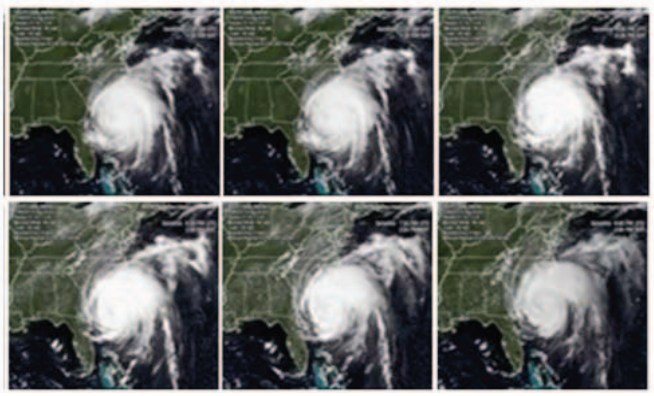


Fig. 1. Example of Satellite Imagery

The example study image materials are obtained through various sites. The data that obtained in the form of video are converted into many images by disassemble the frame in the video. After a picture is taken, the image will be processed further.

E. Research Process

This research is done by performing these steps:

1) Preparing videos and disassemble the videos;

2) Processing the image data to fit in;

3) Designing and building the program to compress satellite imagery sequences by using wavelet;

4) Testing the eight selected wavelet to PSNR and the percentage of compression ratio on satellite imagery sequences.

Processing of satellite imagery sequences with wavelet transformation will results in multi-resolution of the original image. This research used wavelet because the it has the ability to bring out features that special on the images test. The wavelet transformation abilities are useful as a feature extraction method and also reducing the dimension of the input. By using the Learning Vector Quantization (LVQ) neural networks, Test images that have been reduced further are processed for pattern recognition. As the input basis of artificial neural network use some sizes of vector images, which is 16 x 16, 32 x 32 and 64 x 64, and then compares its effect on recognition performance.

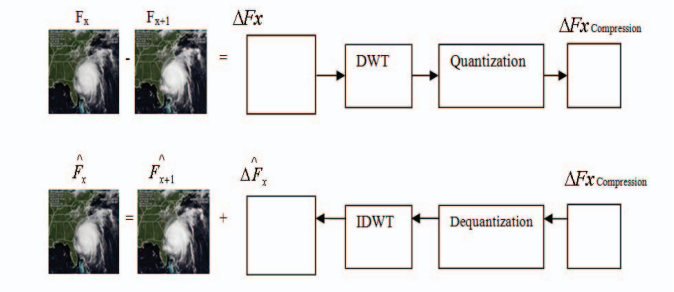


Fig. 2. Compression Process of Satellite Imagery

IV. RESULT AND DISCUSSION

A. Compression of Satellite Imagery Sequences Using Selected Wavelet

This research applies some testing for satellite imagery sequences inter-frame compression to PSNR and compression ratio.

The case that being use for satellite imagery sequences consist of two types of disasters, tornadoes and hurricanes. Each of natural disaster is represented by 10 images sequences with a size of 512 x 512 pixels. The eight wavelets used are Haar, Coiflet1, Coiflet3, Symlet2, Symlet5, 1AJS, AJS2, and AJS 3.

B. Testing of Selected Wavelets to Compression Ratio

Based on Table 1 and Figure 3, for tornado image sequences the results show that the wavelet producing the highest compression ratio is Haar then followed by Symlet 2 and AJS 1. Haar has the highest compression ratio because it has the least amount of filter length, which is 2, while the Symlet 2 and AJS 1 have filter length of 4.

As for the hurricane image sequences it shows that the wavelets producingthe highest compression ratio are Symlet 2 and AJS 1.The Comparison result are can be seen in table 1. Comparison of Selected Wavelets to Compression Ratio.

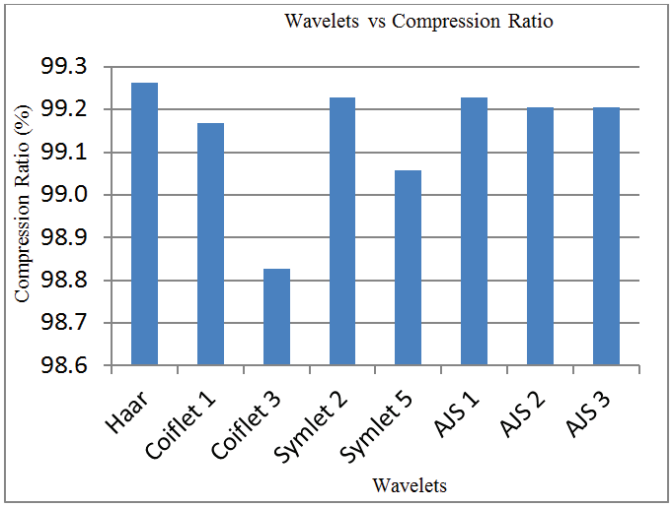
C. Testing of Selected Wavelets to PSNR

Based on Table 2 and Figure 4, for tornado image sequences it showsthat the AJS 2 wavelet yields the highest PSNR value, followed by Symlet 2 and AJS 3. This shows that the AJS 2 wavelet produces reconstruction image that is closest to the original image when compared with the other wavelets.

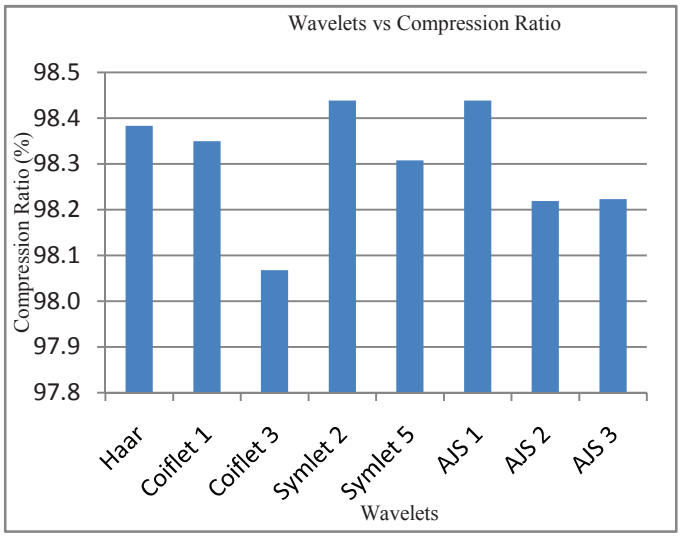
As for the hurricane image sequences, it appears that AJS 2 wavelet yields the highest PSNR value, followed by Symlet 2 and AJS 3. This shows that the AJS 2 wavelet produces reconstruction image that is closest to the original image when compared with the other wavelet.

TABLE I. COMPARISON OF SELECTED WAVELETS TO COMPRESSION RATIO

No	Wavelet	Compression Ratio (%): Tornado	Compression Ratio (%): Hurricane
1	Haar	99.26233	98.38333
2	Coiflet 1	99.16833	98.34967
3	Coiflet 3	98.826	98.068
4	Symlet 2	99.229	98.43867
5	Symlet 5	99.058	98.30767
6	AJS 1	99.22867	98.43833
7	AJS 2	99.20567	98.21867
8	AJS 3	99.20567	98.22333



a. Tornado Image Sequences

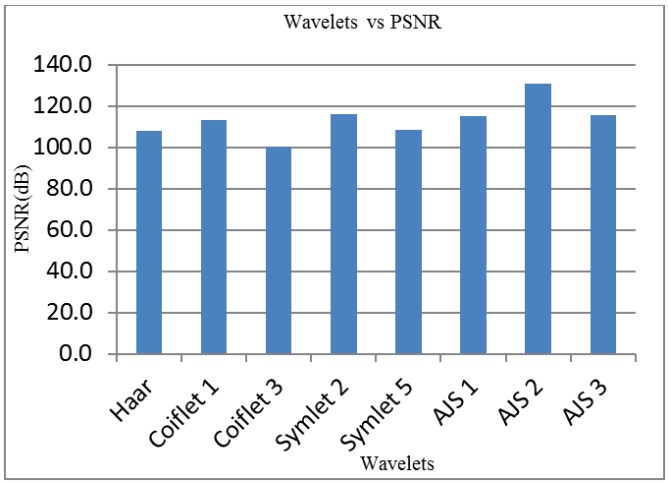


b. Hurricane Image Sequences

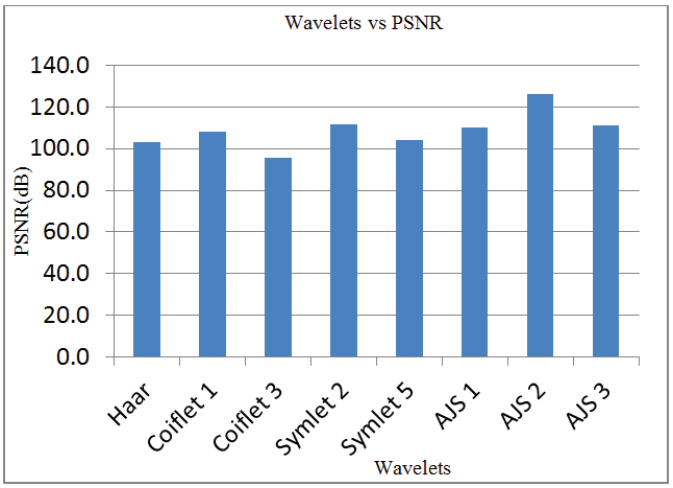
Fig. 3. Comparisons of Selected Wavelets to Compression Ratio

TABLE II. COMPARISON OF SELECTED WAVELETS TO PSNR

No	Wavelet	PSNR (dB): Tornado	PSNR (dB): Hurricane
1	Haar	108.0033	103.11
2	Coiflet 1	113.33	108.2767
3	Coiflet 3	100.1637	95.423
4	Symlet 2	115.9733	111.4967
5	Symlet 5	108.6467	103.94
6	AJS 1	115.07	110.0767
7	AJS 2	130.7467	126.1633
8	AJS 3	115.6133	111.1367



a. Tornado Image Sequences



b. Hurricane Image Sequences

Fig. 4. Comparisons of Selected Wavelets to PSNR

D. Pattern Recognition of Satellite Imagery Sequences

Having obtained the best wavelets to compress the images, the next step is to use the wavelets to the beginning of processing image sequences for pattern recognition. The pattern recognition program with pre-treatment using wavelet and learning process using LVQ.

V. CONCLUSION

Based on the test results and discussion, several conclusions can be made as follow:

1) Three wavelets that produce high PSNR of satellite imagery sequences respectively are AJS 2, Symlet 2 and AJS 3.

2) Pattern recognition of satellite imagery sequences can be preprocessed using wavelet, followed by the learning process using Learning Vector Quantization (LVQ) neural networks.

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