

## SIMULATION AND ANALYSIS DETECTION OF PULPITIS VIA RADIOGRAPH PERIAPICAL USING DCT,WAVELET,AND CURVELET TRANSFORM

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### ABSTRACT

lately the development of technology allow us to do human work easily. for example in medical area, lots of doctor has already use technology as their tools in order to cure or to diagnose disease. Biomedical engineering is the application of engineering principles and design concepts to medicine and biology for healthcare purposes.

Pulpitis as one of the disease that can't be detected with normal eyes ,in order to make decision of this disease doctor need a lots of information including Periapical Radiograph Image and Historical review from patient. after getting those information doctor try to diagnose wheter this patient get pulpitis or healthy,but its not easy to made decision just based on those two things.

Based on the problem above, the author makes "Simulation and Analysis of Pulpitis Via Periapical Using DCT,Wavelet,And Curvelet Transform", which is an application that can allow doctors caught pulpitis of a periapical radiograph

*Keyword : Periapical Radiograph, DCT , Wavelet , Curvelet , LVQ , Pulpitis*

## 1. INTRODUCTION

### 1.1 Background

Development of technology has been helpful to human work. There are a lot of aspect that already been assisted by technology. For example on biomedical area there are a lot of research is done to produce a computer-based diagnostic tool.

One of the dental pulp diseases that can be detected with the technology is pulpitis. Pulpitis is an inflammation of the dental pulp.This disease is one disease that is often experienced by everyone on every layer of society. Dental examination to diagnose the disease early pulp by means sondasi, technical test and electric pulp test (Grossman, 1995). Other tests can be done by inspection using 2D periapical radiographs and the most advanced technology with the 3D results of periapical radiographs.

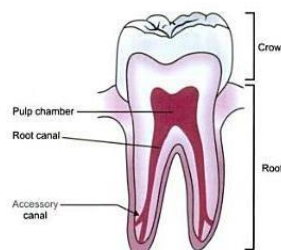
The use of the 3D radiograph results have a very good degree of accuracy, but the cost required is quite expensive (Bitra Dandey Venkata Sridhar and Prasad, 2010). In addition, the diagnosis of this disease can only be done by a specialist dental radiology, dental radiology specialist while in Indonesia is very limited. To facilitate the diagnosis of this disease is necessary tool to interpret the results of radiographs peripikal so with a fairly low cost pulpitis can detect disease with a good degree of accuracy and accessible throughout society, especially in remote areas where there is no specialist dental radiology.

Based on the problem above, the author makes "Simulation and Analysis of Pulpitis Via Periapical Using DCT,Wavelet,And Curvelet Transform and LVQ Classification", which is an application that can allow doctors caught pulpitis of a periapical radiograph.

## 2. BASIC THEORY

### 2.1 Dental Overview

Teeth are hard parts found in the mouth of many vertebrates. The primary function of teeth is to tear and chew food and in some animals, particularly carnivores, as a weapon. Teeth have a protective structure called the tooth enamel, which helps prevent the hole in the tooth, the tooth pulp and dentin deposited shrunk in its place. Teeth consist of email, dentin and pulp. Email is the hardest structure and the outermost, contains 97% calcium and 3% of agarink substances (Grossman, 1995). Dental pulp is the soft tissue that is located in the middle tooth.



**Figure 2.1** Teeth structure

**2.1.1 Definition of Reversible Pulpitis**

Pulpitis is inflammation of the dental pulp resulting from untreated caries, trauma, or multiple restorations. Its principal symptom is pain. Diagnosis is based on clinical finding and in confirmed in X-ray. Treatment involves removing decay, restoring the damaged tooth, and, sometimes, performing root canal therapy or extracting the tooth.

Reversible pulpitis is usually asymptomatic (without symptoms). However, if it appears, the symptoms are usually specially shaped pattern. Application stimulus such as cold or hot liquids or even air, can cause temporarily sharp pain.

**2.1.2 Irreversible Pulpitis**

Irreversible pulpitis is the development or continuation of reversible pulpitis. Severe pulp damage due to taking extensive dentin during operative procedures or disruption of blood flow pulp of teeth due to trauma or mobilization in the treatment ortodonsia can also cause irreversible pulpitis. Irreversible pulpitis is a severe inflammation that can not be recovered even if the cause is removed. Slow or fast pulp will become necrotic (Grossman, 1995, Cohen 2006).

**2.4 DCT (Discrete Cosine Transform)**

A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. Discrete Cosine Transform is used to convert the signal into its fundamental components. Discrete Cosine Transform one of a series of n-dimensional real number  $s(x) \ x = 0 \dots \dots, n-1$ , formulated as follows (sustainably, 2003):

$$S(U) = \sqrt{\frac{2}{n}} C(u) \sum_{x=0}^{n-1} s(x) \cos \left( \frac{(2x+1)u\pi}{2n} \right)$$

with  $u = 0, \dots, n-1$

$$C(u) = \begin{cases} 1, & u=0 \\ \frac{1}{2}, & u=n-1 \\ \frac{1}{2}, & \text{otherwise} \end{cases}$$

with  $u=0, \dots, n-1$

The equation above states  $s$  as a linear combination from basis vectors. transformation coefficients are elements of  $S$ , which reflects the amount of each frequency in the input  $s$ . One-dimensional DCT is useful for signal processing - one-dimensional signals such as sound waveforms. As for the image is two-dimensional, two-dimensional version from required DCT (Watson, 1994). For an  $n \times m$  matrix, 2-D DCT can be calculated by: 1-D DCT is applied to each row from  $s$  and then the results are computed DCT for each column. Transformation formula for 2-D DCT's are as follows:

$$s(u, v) = \frac{2}{\sqrt{nm}} c(u)c(v) \sum_{y=0}^{m-1} \sum_{x=0}^{n-1} s(x, y) \cos \frac{(2x+1)u\pi}{2n} \cos \frac{(2y+1)v\pi}{2m} \text{ with } u=0, \dots, n-1 ; v=0, \dots, m-1.$$

**2.5 Wavelet Transform**

A discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency and location information (location in time). The DWT of a signal  $x$  is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response  $g$  resulting in a convolution of the two:

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n - k].$$

The signal is also decomposed simultaneously using a high-pass filter  $h$ . The outputs giving the detail coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as a quadrature mirror filter. The filter outputs are then subsampled by 2 (Mallat's and the common notation is the opposite,  $g$ - high pass and  $h$ - low pass):

$$y_{\text{low}}[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n - k]$$

$$y_{high}[n] = \sum_{k=-\infty}^{\infty} x[k]g[2n - k]$$

**2.6 Curvelet Transform**

Curvelet transformation is the transformation of plural scale (multiscale) directed that allow almost optimal nonadaptive Sparsa appearance of an object that has a lot of edge. Curvelet transformation first introduced by Candes and Donoho (1999). Curvelet is very interesting because it efficiently resolve problems where the optimal wavelet does not resolve the issue, as the following case example 3:

1. Curvelet optimal in representing object-brimmed especially curved lines.
2. Curvelet optimal in representing the wave propagator.
3. Optimal in terms of reconstructing the damaged image.

To obtain the characteristics of image search a digital curvelet transformsi done in 2-D Cartesian grid f [m, n], 0 ≤ m <M, 0 ≤ n <N.

$$C^D(a,b,\theta) = \sum_{\substack{0 \leq m \leq M \\ 0 \leq n \leq N}} f[m,n] \psi_{a,b,\theta}^D [m,n]$$

Information :

- C<sup>D</sup> : Results Curvelet
- a : The x-axis
- b : The y axis
- θ : Angle Orientation
- M : Rows
- N : Column

**3. SYSTEM DESIGN**

**3.1 Overview of System Planning**

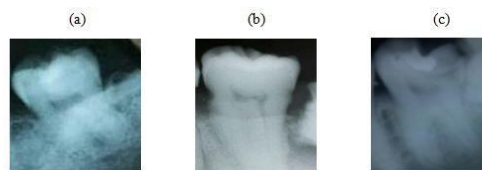
In general, the identification stage of system design can be described in the following block diagram:



**Figure 3.1** Block Diagram of System Model

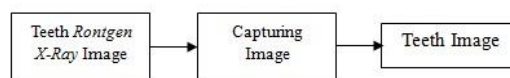
**3.2 Image Acquisition**

The process of image acquisition or recording comes from the periapical radiographs offline using a scanner or camera from the Hospital Dental Faculty of Dentistry, University of Padjadjaran. To simplify the detection process of recording, the position of the image of the periapical radiograph should be in portrait position so that the resulting image to train as follows:



**Figure 3. 2** Image Recording for Data Training

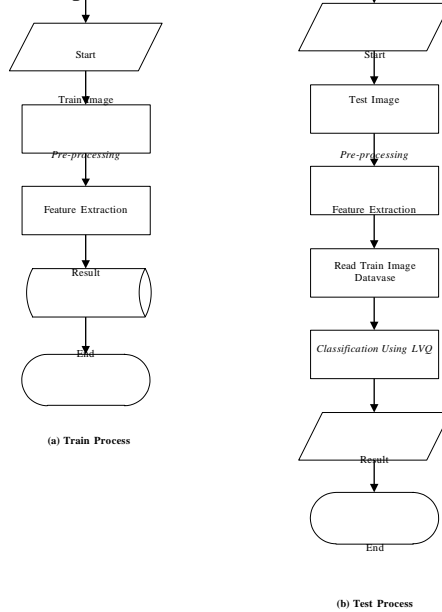
The block diagram of image acquisition process is:



**Figure 3. 3** Image Acquisition Process

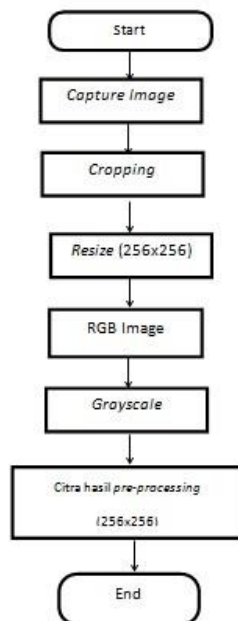
**3.3 Identification Process**

This identification process is conducted by two processes, training and testing process. Training process is the process of finding the pixel value that will be used as reference to the database program, where it will be used for the testing process. The data (periapical radiograph) is entering the pre-processing, feature extraction which is performed with curvelet transform. The result of training phase is stored to the database to be used in testing phase. To determine whether the image has smallest difference with the selected pulpitis value or not, we used identification process. Stages of the identification process for the training and test process can be described as follows:



### 3.4 Pre-processing

Pre-processing is an initial process that is performed on a digital image prior to further image processing. The purpose of pre-processing to improve the quality of the input image is obtained. Here is the flow diagram of the pre-processing on the image:



**Figure 3. 5** Flow diagram of pre-processing

### 3.5 System Performance

Testing process was conducted to determine the performance of the system so that it can be known the advantages and disadvantages of the system. System performance can be measured based on the following parameters:

#### 1. Accuracy System

Accuracy is a measure of the accuracy of the system in recognizing a given input to produce the correct output. Mathematically it can be written as follows:

$$\text{Accuracy} = \frac{\text{Number of Correctly Classified Instances}}{\text{Total Number of Instances}} \times 100\%$$

#### 2. Computation Time

Computation time is the time taken by the system to perform a process. In this system, the computation time is calculated using the Current Time on the mailing list Main Activity, in order to obtain a system of computing time.

#### 3. Mean Opinion Score

In this study physicians and radiologists are asked for the opinion about the system feasibility. The assessment limitations are very helpful (5), assists (4), assists (3), less help (2), and was less helpful (1).

## 4. SYSTEM TESTING AND ANALYSIS

### 4.1 System Testing Phase

The image input in the form of an image taken from a periapical radiograph using the scanner results are copied into the laptop. to obtain this image periapical radiograph image size has a different size. Here are the stages of systemtesting:

Stage One :

15 periapical radiographs with reversible pulpitis diagnosis, 15 periapical radiographs with a diagnosis of irreversible pulpitis and periapical radiograph 10 with a diagnosis of normal teeth have been obtained which then serve as test images. Test image then becomes the input to the preprocessing stage. On this phase image resize be 256x256. System testing is done by comparing the system through the normalization phase system with no normalization, wherein normalization is the phase to change into beraras gray image.

Stage Two :

After the preprocessing stage, the next stage of the segmentation process is carried out using the method Curvelet Transform. This phase is done to obtain the characteristics of each image to determine the detection area. In this test, the parameters used are the mean and standard deviation. In this testing phase will be show the characteristics of each class of dental images.

Stage Three :

The next stage in this system is the process of detection using linear Discriminant Anaylisis and Radian Basis Function where each pixel value in the test images matched with the pixel values in the image of an existing practice in the database. After getting the value difference of each image, the value is used as the detection results approach in which the image diagnosis of reversible pulpitis, irreversible pulpitis or normal teeth.

Stage Four :

The last stage is testing the accuracy and computation time.

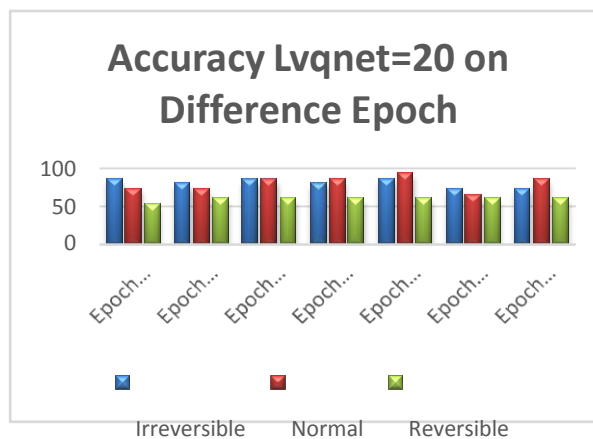
### 4.3 DCT Train Process Accuracy

In this section we will be testing the accuracy of the system using the DCT as the input image feature extraction and classification LVQ as a decisive for input image into three classes, which irreversible pulpitis,

reversible pulpitis, and normal conditions. The parameter that being used are Epoch and Lvqnet(hidden layer).Here are the result of research :

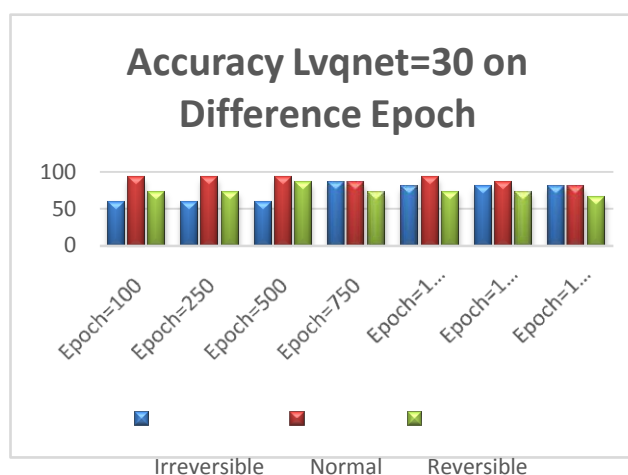
- Using Lvqnet=20 on difference value of Epoch

	Irreversible	Normal	Reversible
Epoch=100	86	73	53
Epoch=250	80	73	60
Epoch=500	86	86	60
Epoch=750	80	86	60
Epoch=1000	86	93	60
Epoch=1250	73	66	60
Epoch=1500	73	86	60



- Using Lvqnet=30 on difference value of Epoch

	Irreversible	Normal	Reversible
Epoch=100	60	93	73
Epoch=250	60	93	73
Epoch=500	60	93	86
Epoch=750	86	86	73
Epoch=1000	80	93	73
Epoch=1250	80	86	73
Epoch=1500	80	80	66



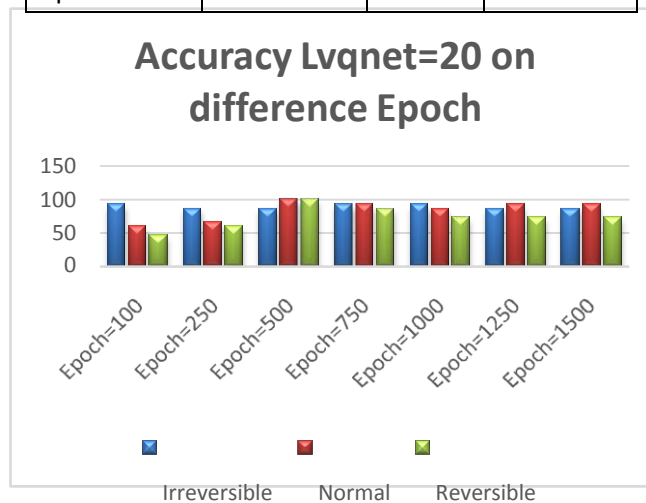
So based on analysis of those train process on difference value of Epoch and Lvqnet that allowed(computerized) by matlab, the Method for train process that has best result is Lvqnet=100 with Epoch=750 and computation time= 13 Minutes 14 Seconds.

#### 4.4 Wavelet Train Process Accuracy

In this section we will be testing the accuracy of the system using the Wavelet (level 4 LL) as the input image feature extraction and classification LVQ as a decisive for input image into three classes, which irreversible pulpitis, reversible pulpitis, and normal conditions. The parameter that being used are Epoch and Lvqnet(hidden layer).Here are the result of research :

- Using Lvqnet=20 on difference value of Epoch

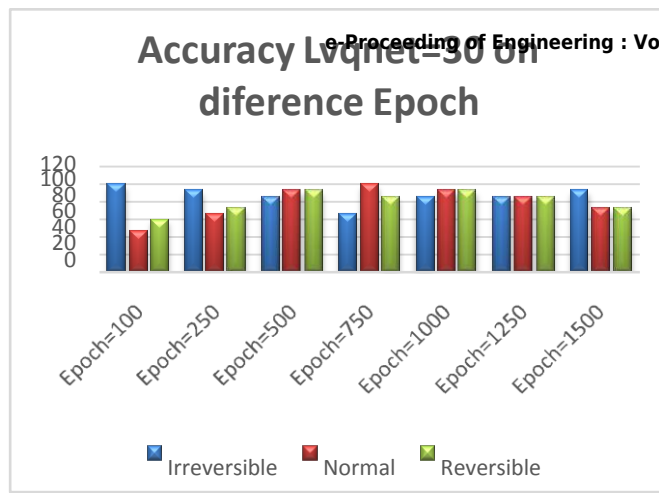
	Irreversible	Normal	Reversible
Epoch=100	93	60	46
Epoch=250	86	66	60
Epoch=500	86	100	100
Epoch=750	93	93	86
Epoch=1000	93	86	73
Epoch=1250	86	86	86
Epoch=1500	86	93	73



- Using Lvqnet=30 on difference value of Epoch

	Irreversible	Normal	Reversible
Epoch=100	100	46	60
Epoch=250	93	66	73
Epoch=500	86	93	93
Epoch=750	66	100	86
Epoch=1000	86	93	93
Epoch=1250	86	86	86
Epoch=1500	93	73	73





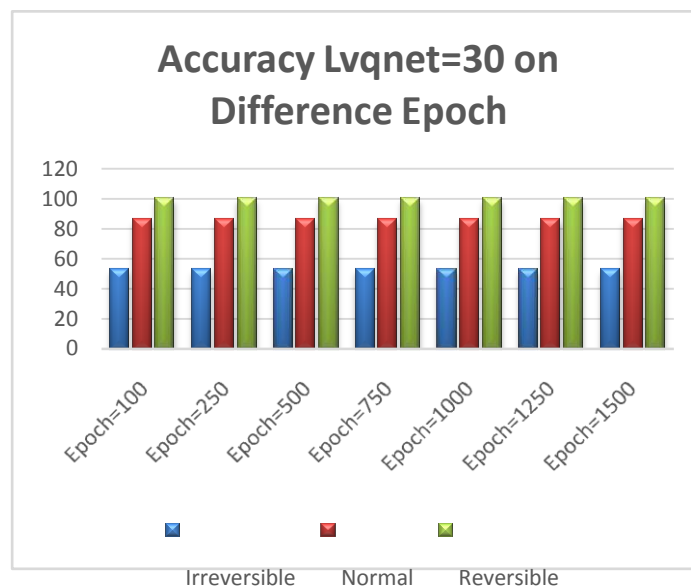
So based on analysis of those train process on difference value of Epoch and Lvqnet that allowed(computerized) by matlab, the Method for train process that has best result is Lvqnet=20 with Epoch=500 and computation time= 3 Minutes 52 Seconds.

### 4.5 Curvelet Train Process Accuracy

In this section we will be testing the accuracy of the system using the Curvelet (as the input image feature extraction and classification LVQ as a decisive for input image into three classes, which irreversible pulpitis, reversible pulpitis, and normal conditions. The parameter that being used are Epoch and Lvqnet(hidden layer).Here are the result of research :

- Using Lvqnet= 30 on difference value of Epoch

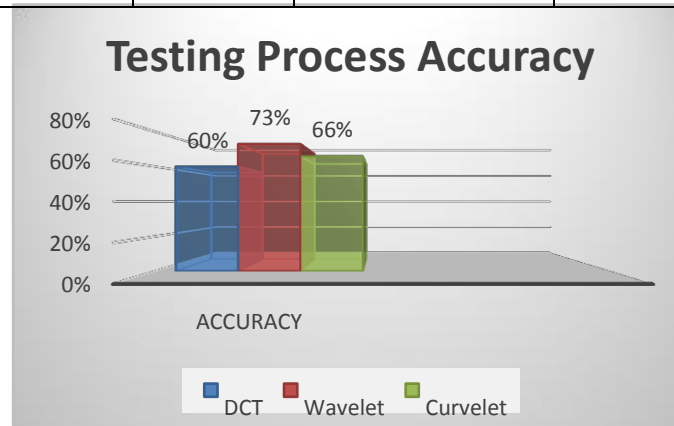
	Irreversible	Normal	Reversible
Epoch=100	53	86	100
Epoch=250	53	86	100
Epoch=500	53	86	100
Epoch=750	53	86	100
Epoch=1000	53	86	100
Epoch=1250	53	86	100
Epoch=1500	53	86	100



## 4.6 Test Accuracy Result Comparison

Here are the result from every method testing using LVQ classification. The value that showed is accuracy value of test process toward selected train process.

Method	DCT	Wavelet	Curvelet
Accuracy	60%	73%	66%



After doing training and testing process the result of accuracy shows that the value of accuracy from training process and then continue with testing process to classify the data into 3 classes using LVQ method that has been selected from previous sub which is Epoch and Lvqnet selection shows that Wavelet has the biggest value on accuracy with 73 percentage .

## 5.1 Conclusion

From the results of the testing and analysis has been done on the design of periapical Pulpitis detection system, The conclusions to be drawn from this final project are as follows:

1. The level of accuracy obtained by Wavelet method is 73%. Followed by Curvelet with 66% and DCT with 60%. With computation time 7 second for Wavelet, 10 seconds for DCT, and 12 seconds for Curvelet.
2. Wavelet is the best method among those 3 based on this particular research.
3. The Value of Epoch and Lvqnet for Wavelet as the most accuracy method are: Epoch = 500 Lvqnet = 20.
4. The Change of Epoch and Lvqnet on LVQ classification can affect the accuracy value and computation time.
5. Based on the MOS, this application can be said to have helped, easy to use and very attractive to users.

## 5.2 Suggestion

The suggestions for further research are as follows:

1. For better result try to use medical scanner to obtain radiograph periapical data.
2. For better result try to use same tooth for all data both train or test.
3. Try validates data to a lot of dentist for a better result.
4. The application can be used in realtime, using mobile phone cameras and the results can be directly detected.

**Bibliography**

- [1] Chetan. <http://www.drchetan.com/reversible-pulpitis-hyperemia-hyperactive-pulpalgia.html>, terakhir diakses tanggal 10 Januari 2013
- [2] Groszman. 1995. *Ilmu Edodontik Dalam Praktek*. Jakarta : EGC
- [3] Hery Mauridhi, P dan Arif Muntasa. 2010. *Konsep Pengolahan Citra Digital dan Ekstrasi Fitur*. Yogyakarta: Graha Ilmu
- [4] Kamdi, Shilpha dan R.K Krishna. 2012. "Image Segmentation and Region Growing Algorithm". *International Journal of Computer Technology and Electronics Engineering (IJCTEE)*. 2, 104-106
- [5] Mitchell, Richard. "Dental Health Advice". <http://www.dental-health-advice.com/tooth-nerve-pain.html>, terakhir diakses tanggal 10 Januari 2013
- [6] Radial Basis Fuction, <http://www.mathworks.com/help/nnet/ug/radial-basis-functions.html>, terakhir diakses tanggal 15 Mei 2013.
- [7] Demanet, Laurent. (2007). *Curvelet.org*. [Online]. Tersedia: <http://www.curvelet.org/software.html> [7 November 2011]
- [8] Putra, Darma. 2010. *Pengolahan Citra Digital*. Yogyakarta: Andi  
Sridhar, Bitra dan Dandey Venkata Prasad. "Finding 3D Teeth Positions by Using 2D Uncalibrated Dental X-Ray Images". PhD