Comparative Evaluation on Iris Recognition Performance

Bens Pardamean and Ingrid Christiani

***Abstract*—** The study is to compare the performance of iris recognition software between the open source (Libor Masek) and the commercially available (VeriEye by Neurotechnology). There are five processes to evaluate the performance: 1) resize the images' resolution from 1280 x 960 to 640 x 480; 2) convert the images from JPEG2000 to JPEG format; 3) convert the images into grayscales; 4) run the images with both Libor Masek's and VeriEye software; 5) measure the performance of the two software using Receiver Operating Characteristic (ROC) plot and the operational time framework. The ROC plots show that VeriEye software performs better than Libor Masek's. There is significant difference in the processing time between the two software.

***Keywords*—** Bath images, Biometric, Iris recognition, Libor Masek, VeriEye

I. Introduction

Biometric technology is an automatic method of identification of a person based on their physiological or behavioral characteristics such as fingerprint, iris pattern, facial feature, voice, odor, signature, and speech [1]. The use of biometric technology has increased tremendously nowadays such as in banking for authentication, apartment complex for access control, airport security for border control, and national identification. By exploiting its capabilities, biometric technology potentially can be a solution for the problems of security [2], [3].

According to Jain, Ross, and Prabhakar [1], there are several requirements that can be used to meet the physical characteristics of biometric indicators. Universality means that every individual using a system must own the trait. Distinctiveness means the trait must be sufficiently different for every individual in the population so that an individual can be distinguished from one another. Permanence relates to the characteristic is unchangeable over time with respect to the specific matching algorithm. Collectability and measurability relate to the ease of acquisition and measurement of the trait. Performance relates to the accuracy, speed, and robustness of technology used.

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Although no single biometric can meet all the requirements of every possible application, this study was specifically focus on the biometric performance on the iris characteristic.

Additionally, Jain, Ross, and Prabhakar [1] also mentioned the issues that should be considered in a practical biometric system for personal recognition namely acceptability and circumvention. Acceptability associates to how well individuals accept the technology. Such as their willingness to have their biometric trait captured and assessed by a biometric system. Circumvention relates to the ease of a trait might be imitated utilizing an artifact or substitute apparatus. It is about fraud against the system itself.

With all its advantages, there are several issues facing biometric technology. According to Kountchev, Todorov and Miranova [20], and Chong, Teoh and Ngo [21], those challenges are as follows:

- the slow data transfer, resulting from the large amounts of data needed for the authentication;
- the slow decision speed due to processing technologies that create lack of productivity, waiting lines, and frustration on the part of the persons being authenticated;
- the requirement to maintain large databases containing the biometric data;
- biometric feature cannot be replaced once it is compromised.

Among biometric technology, iris has attracted a lot of attention [4] because of its physical characteristics such as the uniqueness of the iris pattern and the system accuracy [5]. The iris is considered an internal organ located behind the cornea which makes it very difficult to modify, and if it happens, the risk will be at the eye and cannot be rebuilt [6]. Iris has much visual information in the texture. "Textures are complex visual patterns composed of entities, or sub patterns that have characteristic brightness, color, slope, size" [7]. Beside it, iris is made up from four layers [8] that can be detailed as follows:

1. Anterior border layer is the denser exterior layer with more pigmentation
2. The second layer is stroma which contains most cells, collagen, macrophases, and melanocytes

3. The third layer allows for contraction and dilation that contains the sphincter and the dilator muscles which control the amount of light entering the pupil [5]
4. The back layer is heavily pigmented and makes iris opaque

Performance has always been an important factor in biometric technology. Various tests were already conducted by National Institute of Standards and Technology (NIST) on the algorithm accuracy whether it was for iris, face, or fingerprint system [9]. In an environment where throughput and security are priorities, there is no place for a bottleneck that could be caused by failures in identifying an individual.

This study aimed to evaluate the performance between two different software. One was VeriEye by Neurotechnology [10] which is commercially available on the market. And the other one was Libor Masek [12] which is an open source software.

VeriEye 2.2 iris recognition software was released in 2009 by Neurotechnology that began research and development in iris recognition in 1994. The software was recognized as one of the most reliable and accurate software for iris recognition by NIST [10]. VeriEye product was based on John Daugman's methods which were patented [10]. Daugman's techniques were based on an integro-differential equation which was used to segment and to find the geometric parameters of the iris images [11].

Libor Masek iris recognition software was Masek's study project in 2003. He developed an open source iris recognition software based on Daugman's method by using MATLAB®. His project goals were to do automated segmentation of the iris and to do investigation of optimum parameters for biometric template encoding [12].

The performance measurement that were compared were the error rates, False Accept Rate (FAR) and False Reject Rate (FRR). Additionally, the time that was used in the operational time framework formulated by Elliott, Kukula, and Lazarick [13].

FAR is the proportion of transactions with wrongful claims of identity that are incorrectly confirmed [17] and computed by International Organization for Standardization (ISO) [14] as:

$$FAR = FMR \times (1 - FTA)$$

Where FMR is False Match Rate, and FTA is Failure to Acquire

FRR is the proportion of transactions with truthful claims of identity that are incorrectly denied [17] and computed by ISO [14] as:

$$FRR = FTA + FNMR \times (1 - FTA)$$

Where FNMR is False Non Match Rate.

According to ISO [14], FAR and FRR will depend on the three situations:

1. The decision policy,
2. The matching decision threshold, and
3. The threshold for sample quality.

II. PROBLEM FORMULATION

As of this study was conducted, there has been no comparison between the performance of the commercially available and the open source software namely VeriEye and Libor.

The main purpose of this study was to evaluate the performance of the commercially available and the open source software using Bath iris images database. The study can contribute to developers and end users when they are choosing which software to use if budget is a problem but performance is not a requirement. The result should demonstrate whether the open source software (Libor Masek) would perform as good as the commercially available one (VeriEye) in terms of their FAR, FRR, and the time. The other benefit is to open the door for developing an application that can incorporate the open source algorithm if the result of the study is promising.

III. METHODOLOGY

The Bath iris images database was used for this study. 1,000 iris images (from 50 eyes with 20 images taken for each eye) were selected from the full Bath iris image database of the random community at Bath University, UK. The database contains very high quality images [15].

The identification mode was used in this iris recognition study. In this identification mode, the biometric system performs a one-to-many comparison against the Bath iris image database in attempt to establish the identity of an unknown individual's iris image. The system succeeds in identifying the individual if the comparison of the iris image to a template in the database falls within a previously set threshold. Identification mode can be resulted either for 'positive recognition' or for 'negative recognition' of the person [1], [3].

The study utilized a PC with Windows XP Professional SP2 installed, with Intel® Core™ i3 CPU 540 at 3.07 GHz, and RAM at 3.24 GB DDR2. The following is the list of software that was part of the study:

- MATLAB® R2009 was used to modify and to run Libor Masek's software and to compress images
- VeriEye software by Neurotechnology
- Microsoft Excel for data entry

- SPSS to perform statistical analysis (T-test)
- Ivan Image Converter to convert the JPEG2000 to JPEG uncompressed format

During the course of the study, there were several limitations that were discovered and required modifications. The source codes for Libor Masek's software must be modified for the calculation of the FAR and FRR since it was very time consuming in processing some images. Other limitation was the need of conversion for the size and format of Bath iris image database in order to work with Libor Masek's software.

IV. PROBLEM SOLUTION

The steps that were taken to evaluate the performance of the software were as follow:

1. Resize the Bath iris images resolution from 1280 x 960 to 640 x 480 using a MATLAB® program
2. Convert the images from JPEG2000 to JPEG format using Ivan Image Converter
3. Convert the images into gray scales format using MATLAB® program
4. Run the images on both sofware, the error rates and the time were acquired
5. Run analysis on the performance using Receiver Operating Characteristic (ROC) generator and SPSS software

The experimental design for this study can be described using the flowchart as shown in Figure 1.

The first step was to resize the Bath iris image resolution from 1280 x 960 to 640 x 480. The previous research by Ives, et al [18] found that statistically, there is no different between the original image and the image which has been compressed to 50% in JPEG2000 format and "the compression does not deteriorate performance but in some case, even improves it slightly" [19].

The second step was to convert the images from JPEG2000 to JPEG format in order to comply with the compatibility of VeriEye 2.2 standard SDK.

The third step was to convert the images into gray scales in order to comply with the compatibility of Libor Masek's software.

The operational time framework that was used in the study is adapted from Elliott, Kukula, and Lazarick [13]. The operational time framework was adjusted to only concern with the sample processing and biometric subsystem decision time. The adapted framework is shown in Figure 2.

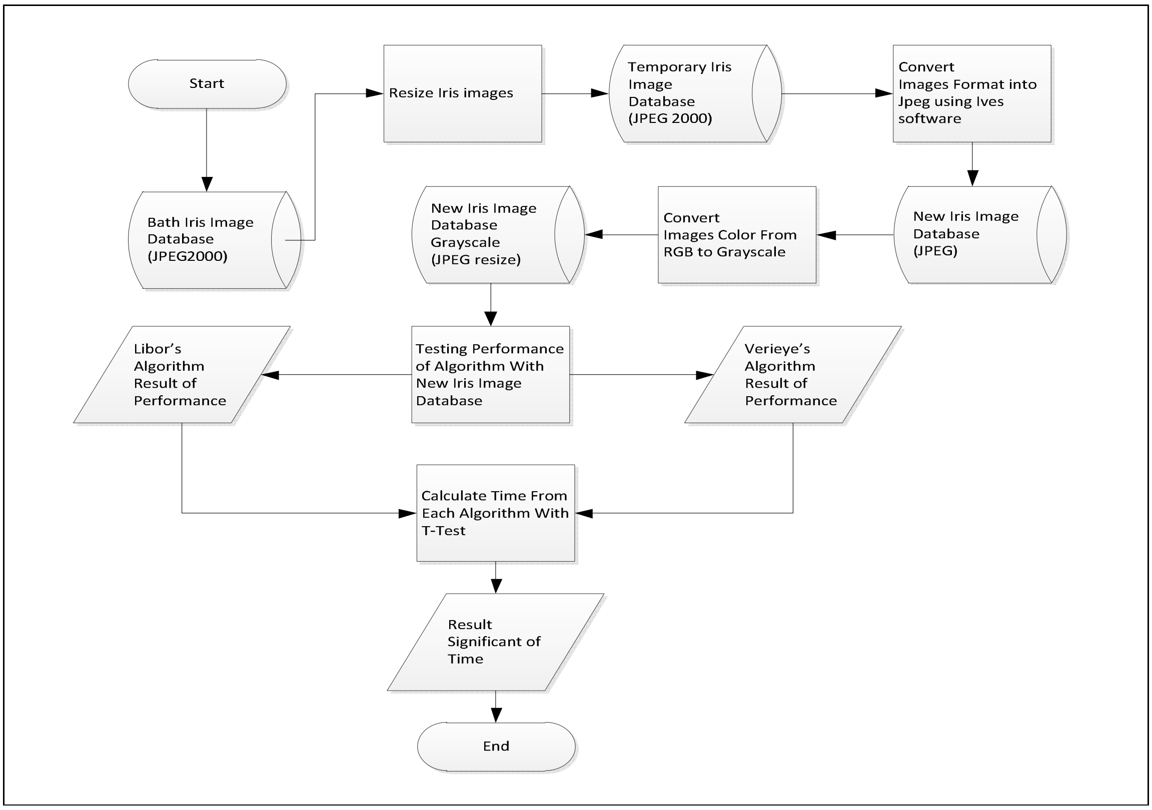

Figure 1. The study design used for comparative evaluation on iris recognition performance

The sample processing time is the phase where it calculates the time of feature extraction and during the matching that produces Hamming Distances. The next process is to calculate the biometric subsystem decision time. The biometric subsystem decision time in the study consists of a process that determines whether the images were accepted or rejected based on the threshold. The FRR and FAR are also calculated in this step.

The statistical analysis method used in this study was the T-test analysis using the SPSS software. The T-test was used to analyze the performance (time) between Libor Masek's and VeriEye software. The images were run three times on both software to see the data reliability it produced in the process of identification. Both software were set equally during the data run.

The FAR and FRR were calculated. ROC plots were used to display the relationship between the errors. The ROC curves that were produced by both software were compared as well.

For this study, a modification was necessary for the Libor Masek's source codes. Libor Masek's software was developed for educational purpose, thus only a minor modification on the source codes was needed in order to give the same comparison to the VeriEye.

The modifications for the Libor Masek's source codes are shown below.

Calculate FMR and FNMR using formula from Li [16]:

```
D0=Intra;
D1=Inter;
Dmin=min([D0 D1]);
Dmax=max([D0 D1]);
N0=length(D0);
  N1=length(D1);
  step=(Dmax-Dmin)/N;
  cnt=1;
  forth=Dmin:step:Dmax
  FNMR(cnt)=sum(D0>th)/N0;
  FMR(cnt)=sum(D1<=th)/N1;
  cnt=cnt+1;
  end
```

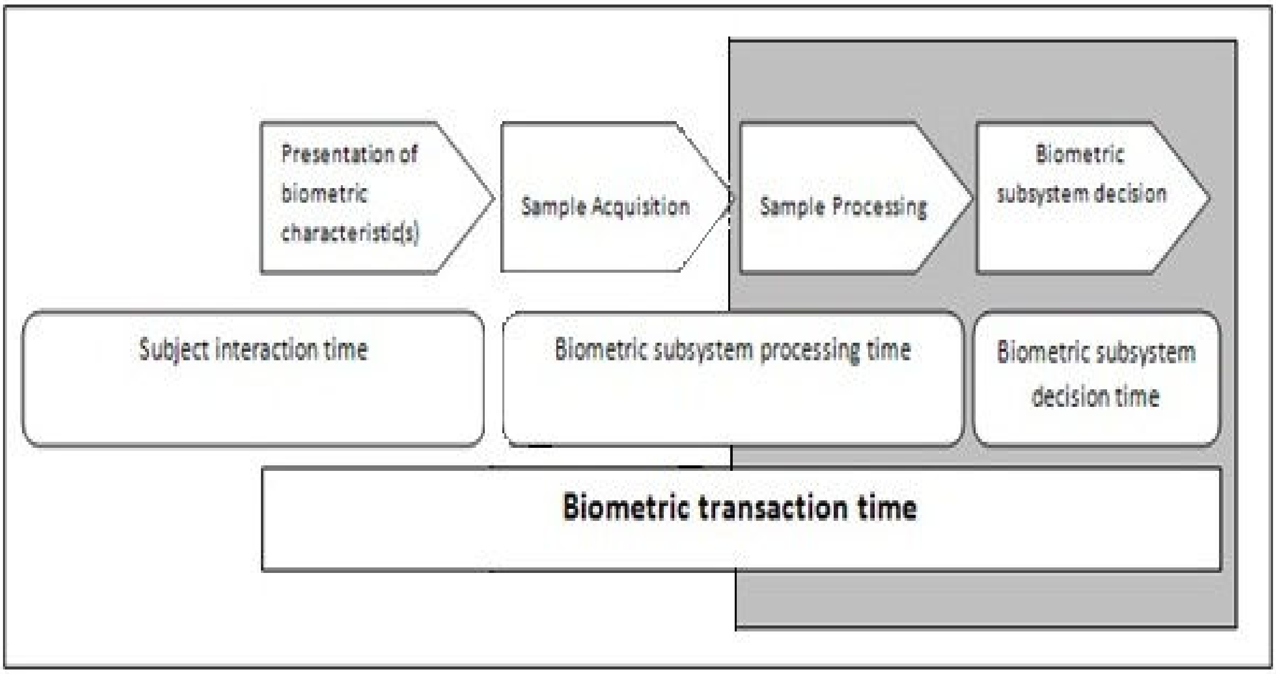

Figure 2. The operational time framework which was adapted from Elliott, Kukula, and Lazarick [13].

Calculate Hamming Distance:

```
for sub=sub1:Nsub

for j=sub+1:Nsub
```

And to avoid any repeated images, the following code will be used:

```
str=num2str(sub);
   str1=['template' str];
load(str1);
   template1=template;
         mask1=mask;
```

V. RESULTS

Table 1 shows the result from the T-test analysis on the time performance.

	N	Mean (sec)	SD (sec)	*p*-value
VeriEye	1000	0.180	0.024	< .05
Libor Masek	966	0.413	0.132	

Table 1. T-test result for the time performance.

Based on the time performance, the result showed that VeriEye software was better than Libor Masek's software ($p < .05$). In fact, Libor Masek's software was only able to process 966 images because there were segmentation errors with 34 images. Libor Masek's software failed to segment the images might be caused by the non centered location of the iris as shown in Figure 3.

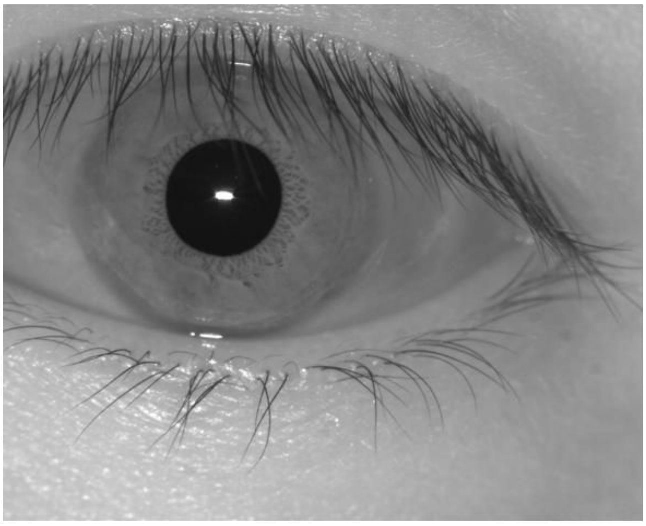

Figure 3. Segmentation error was found on the image above when processed using Libor Masek's software.

The position of the iris in Figure 3 was not in the centered position like the other segmented images (Figure 4 and Figure 5) which caused the Libor Masek's software unable to detect the iris and thus the error occurred. The error was not calculated as Failure to Acquire (FTA), because if it did, it would cause the MATLAB® to stop running the process.

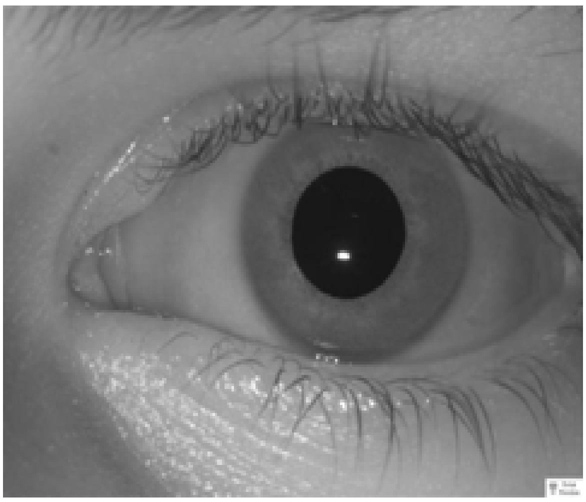

Figure 4. Original Image

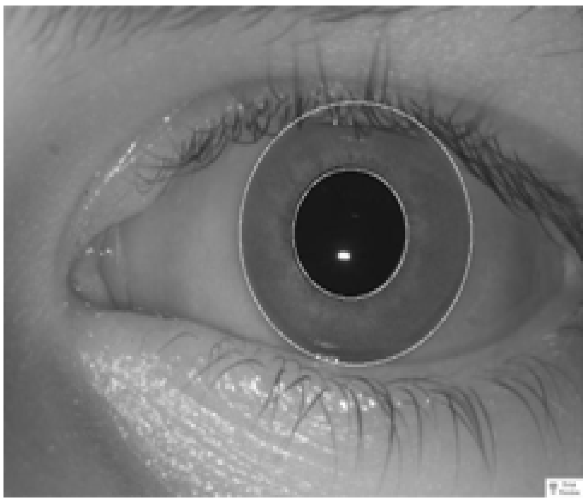

Figure 5. Segmented Image

The ROC graph is a visual characterization of the trade-off between the FAR and the FRR. Typically, the matching software performs a decision based on a threshold which determines how close to a template the image needs to be for it to be considered a match. If the threshold is reduced, there will be less false non-matches but more false accepts. Analogously, a higher threshold will reduce the FAR but increase the FRR accordingly.

VeriEye software did not produce any FTA. VeriEye algorithm produced perfect zero FAR and FRR as shown in the Figure 6 below.

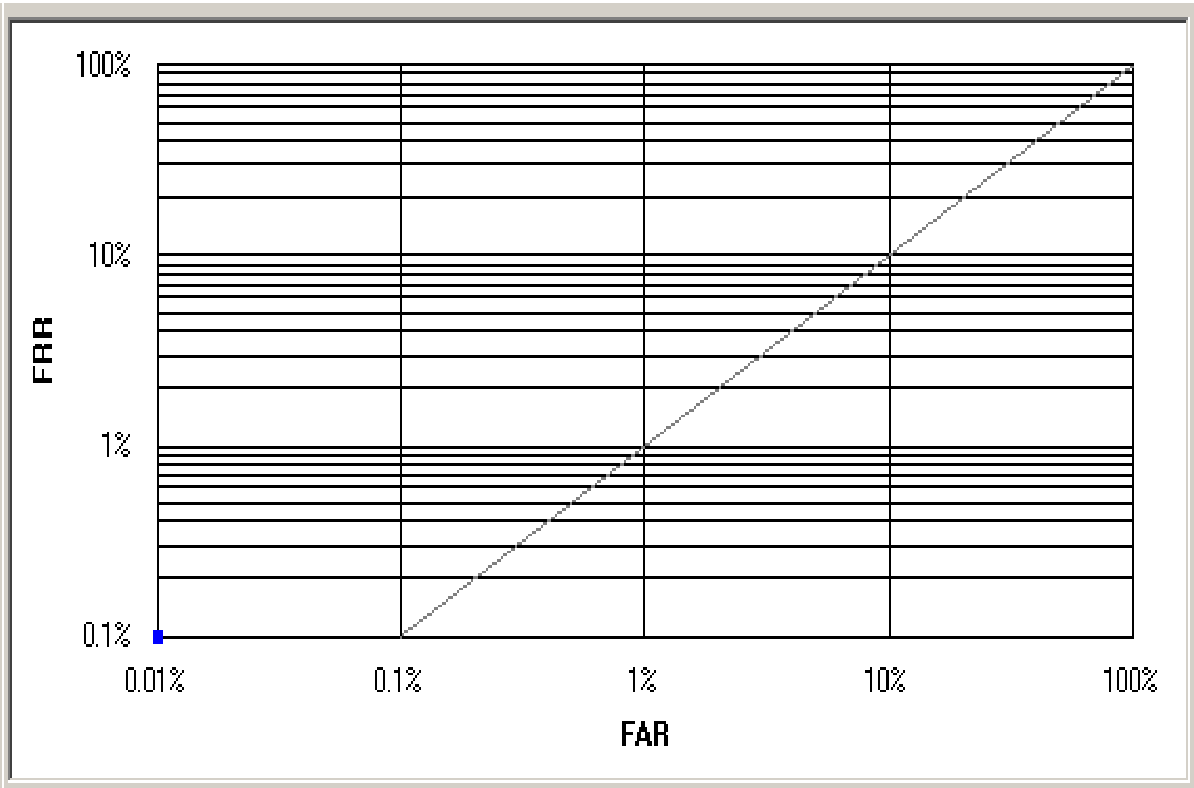

Figure 6. ROC plot for VeriEye software

Libor Masek's software produced 76% of FRR and 0% of FAR as shown in Figure 7 below.

As it was statistically significant difference on the time performance, the ROC plots also showed VeriEye software performed much better than the Libor Masek's software.

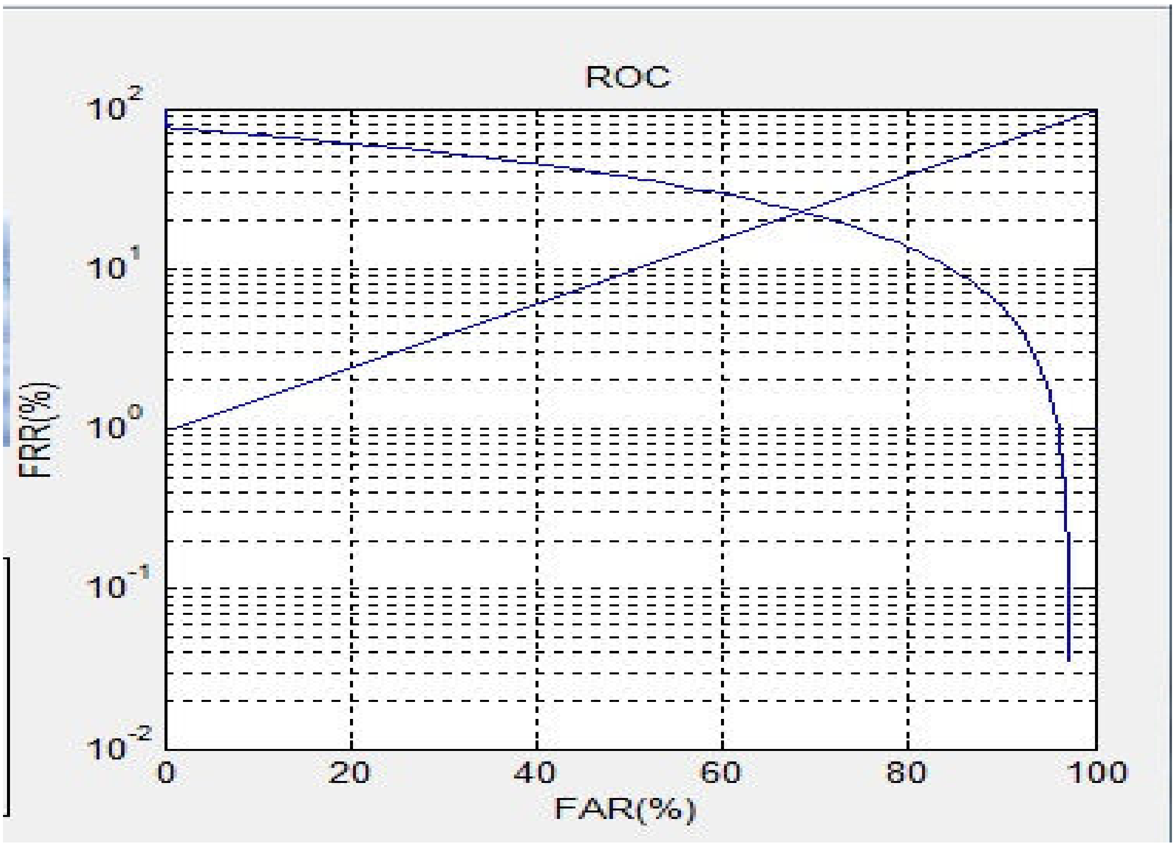

Figure 7. ROC plot for Libor Masek's software

VI. CONCLUSION AND RECOMMENDATIONS

In term of the time factor, this study concluded that the Libor Masek's software did not perform as well as the VeriEye software.

Further study can still be conducted to improve the Libor Masek's algorithm. With its open source platform, this could attract developer to incorporate the algorithm in their application. Perhaps it could also be translated into other programming languages other than MATLAB® to evaluate its performance in other programming languages.

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