

**PRELIMINARY STUDY IN EVALUATION OF
UNCONSTRAINED MINIMUM AVERAGE CORRELATION ENERGY
(UMACE) FILTER USING RAW VIDEO DATA FROM RUNNING
EVENT**

By

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DECLARATION

I hereby declare this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

Abstract

The purpose of the study is to evaluate the performance of UMACE filter for the data taken during a running event, Kelantan Open Run 2015. The images were taken during the running event were classified as raw data for uncontrolled environment. The performances of the filter were also compared to the images from controlled environment, where the lighting and the posture were kept almost the same. The images from controlled environment were taken from three volunteers. The evaluation process were done and observed using the peak-to-side lobe ratio (PSR) value, where the method already is used in most of face recognition method. The threshold of the PSR value were set to certain value based on the range of PSR value to evaluate the specificity, sensitivity, precision and accuracy of the UMACE filter in the face recognition process. The evaluation process also used different number of training images from 2, 5 and 10 to find the optimal number of training images for the UMACE filter. MatLab software was used for the study. The results of PSR value using raw data from uncontrolled environment and from controlled environment are not consistent. Histogram equalization method used as an image enhancement method also showed inconsistent result. Thus, producing low value of sensitivity, specificity, precision and accuracy percentage in most of the evaluation process except for the process using two training images where the accuracy rate at the highest value between 79 to 80 %. Optimal number of training images used also showed inconsistent result. From the result, further studies are recommended in order to improvise the performance of the UMACE filter before it can be implemented in the running event. Another image processing method should be explored to increase the overall performance of the UMACE filter.

Abstrak

Tujuan kajian ini dijalankan adalah untuk menilai keberkesanan *UMACE* untuk imej yang diambil ketika Larian Terbuka Kelantan 2015. Imej-imej tersebut akan dikelaskan kepada dua kategori iaitu imej yang diambil dalam situasi terkawal dan imej yang diambil dalam situasi sebenar. Keberkesanan *UMACE* akan dibandingkan antara dua kategori tersebut dimana postur dan cahaya diambil dalam keadaan terkawal. Penilaian tersebut dijalankan dan dilihat berdasarkan nilai *PSR*. Kaedah penilaian ini digunakan oleh majoriti penyelidik sebelum ini. 1 nilai akan ditetapkan bagi menentukan ketepatan dalam mengenalpastian imej dan sensitiviti kaedah yang digunakan. Penilaian juga berdasarkan bilangan imej yang digunakan sebagai *mask* juga dilakukan bagi mengenalpasti bilangan *mask* diperlukan untuk mendapat hasil yang optimum. Hasil ujian yang didapati tidak begitu konsisten daripada kedua-dua kategori tersebut. *Histogram equalization* digunakan untuk menambahbaik imej yang diperolehi juga menunjukkan hasil yang tidak begitu memberangsangkan. Kaedah tersebut memberi nilai ketepatan dalam lingkungan 79 ke 80%. Bilangan *mask* yang optimum juga menunjukkan hasil yang tidak konsisten. Daripada penilaian ini, lebih banyak kajian yang diperlukan untuk menambah baik fungsi *UMACE* sebelum diimplemen dalam acara larian jarak jauh. Kaedah pemprosesan imej yang lain juga hendaklah dikaji untuk meningkatkan kebolehan *UMACE*.

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Chapter 1 Introduction

1.1 Background of the study

Technologies have been one ways to improve our quality of life in order to minimize error and improving the consistency. Technology which means the science of craft where we can build anything we want to ease our life (Universal technological dictionary , n.d.) . If centuries ago we need to remember many things about the things happen yesterday using our cognitive function which is memory, nowadays we have camera and also videos to rewind the thing that happen in the past. We also have memory card to help the people with short term memory problems.

Face recognition technologies are being developed in the past. Usually they use the face recognition to capture the criminal by playing or rewind the video captured using CCTV. As example in United States of America, the airport used face and fingerprint recognition system before giving permission to the foreigner to enter the country named . The picture and fingerprint captured will be sent to known criminals' database to avoid any crisis inside the country. According to Rolfe (2014) in his article at Heraldsun.com, the face recognition help the sports organization to prevent any troublemakers from making havoc. A hi-tech camera will prevent the repeat offenders from coming into major events and creating havoc at public areas.

Aside of that, technology also help to verified many things in sport and make them entertaining and transparent toward the decisions. According to the Gibbs (2014), there are many technologies that being used in sport. Hawk-eye technology that used in cricket and tennis were developed in 1999 by Dr. Paul Hawkins and engineers at Subsidiary Roke Manor Research Limited. The technologies had been use for referral and many major tournaments in tennis. However, every technology has their flaws as said by Bishop (2015) in the website where the goal-line technology had taken over the human element in decision making which usually done by the referee. That may be true; however, it may further assist rather than relieve the judges from their responsibilities. Other concern was the cost to implement the technology. Yet again, it may be cost effective when appropriately implemented.

The video recording also help to build the integrity of sport where there are too many cheating measure. Video replay had been used as judge for hockey tournament as the umpire will refer to the video if the player claim something foul happen but unnoticed by the umpire. It aids the umpire in making the right decisions. The future might see that technologies help the sports industries to expand further and become more interesting.

Running events is more popular nowadays in Malaysia, as it is also being promoted in Malaysian campaign to promote active and healthy citizen. Most of the running events are done by volunteers, it is involved a lot of process. It is a quick process that needs a lot of attention from the volunteers.

1.2 Research Statement

Running events nowadays become a trend where we can see there are many organizers everywhere want to organize long distance or cross country events in their places. There is at least one event for running in any places in Malaysia. However, the qualities of the events are going to be evaluated as they going to pay to run in the events. Some of them want to run for fun so they didn't care about the money or prizes and they just want to have fun.

What about the professional or serious runner? Are they going to run again in the same events if the organizer didn't care about the technical aspect? In order to avoid cheating measures, the organizers make the checkpoint to make sure that the runners didn't cross or take a short cut into the finishing line. The checkpoints were going to have a sum of people that many volunteer will write down the runner's bib numbers at each check point. However, humans also make mistakes too and they have their own habitual. Some of them cannot remember many numbers in a single period but some of them can because of the redundancy of information gather in one time (Miller, 1956).

Organizing marathon or any cross country event needs a lot of process to be done, thus it will involve many volunteers. This study explored the possibilities of implementing the technology in one aspect of running events, runner recognition at the checkpoint. This method will be used to assist the process that need to be done at the checkpoint. By doing this research, hopefully in the future it is not solely depends on many volunteers. This

method will help in reducing the manpower for running events thus cutting the cost needed for running a marathon or a long distance event. We hope that this method can improve the quality of the events and avoid any difficulties in the future.

1.3 Objective

- To evaluate the performance of UMACE filter using a video of the running event.

Specific objective

- To evaluate the performance of pre-processing step for UMACE filter.
- To evaluate the performance of using data gained from video captured during running event using UMACE filter.
- To evaluate the classification rate of UMACE filter in live events.

1.4 Research Question

- How well UMACE filter using raw data under uncontrolled circumstances?
- How the performances of UMACE filter after the implementation of histogram equalization?
- How well the classification rates of UMACE filter under specificity and sensitivity?

1.5 Significance of Study

This technology will help in reducing the manpower for running events thus cutting the cost needed for running a marathon or a long distance event. At every checkpoint, many volunteers involve in writing the runners' number in order to avoid the query later .

This study explored the possibilities at implementing the computer technology in some process in the running events especially at every checkpoint. Computer aided technology can be used to aid the process at every checkpoint for verification process. One of the possibilities is implementing the face recognition process at the checkpoint to aid the process of recognizing the runner and recording his or her number.

Chapter 2 Literature Review

2.1 Face recognition usage

Previous study done by Liu (2014), shows that all the research that tested face recognition algorithm were using static database such as FERET, FRVT, and FRGC. All of these databases were in controlled environment and the algorithm worked perfectly in the controlled situations. However, when implemented at dynamic or uncontrolled environment such as the workplace, the target correct detection rate goes up to 237% and target false recognition rate falls to 78%. Next, the target false negative drop to 63% and Non-Correct Rejection rate increased to 97% for the system that have fundamental index lower than 90%.

2.2 Recognition technologies in sports

Previous study by Flintham et al. (2015) showed that the apps which is RunSpotRun can detect the runners which is entered by the spectators in order to detect their favorites runner. Through the apps, they can follow the stories about the selected runner according to their Racing Bib Number (RBN). They used the crowdsourcing method to build a database from online source so they can follow the story along the races. However, it becomes difficult as the spectators cheering for the runner and also when the frames become crowded, thus it becomes difficult situation to detect the runners.

Messelodi & Modena (2013) shows that they can do a tracking system during sporting events broadcasts to track the desired player using their number and name placed on

their jerseys. Through this app, they can follow their performance of the player throughout the game. They use the OCR-ed text to compare with a known list of athlete's names or number to provide a presence score for each athlete. Template matching technique is applied in order to track text region on their jerseys in subsequent frames. However, the app cannot read the blurred or distorted text thus denser labeling of the video sequences is excluded. This method is fast, robust and reliable for tracking or detection apps for field player.

Another method proposed by Idan Ben-Ami, Tali Basha, & Shai Avidan, (2011) used the Stroke Width Transform or SWT in order to manage the variability images in the pictures frame during the detection process. They study the application of this detection app in the wider context of detecting or recognizing text in natural environments. By using the fact that the identification number will be placed at the front, they use face detector to create hypotheses regarding to the racing bib number or RBN location and scale. Next, SWT method is used to detect the location of tag numbers before they fed it into Optical Character Recognition (OCR) engine. However, this app depends on how well the face recognition result before tracking the tag numbers thus bad camera speed or quality might affect the accuracy of the recognition process.

2.3 Minimum video quality for facial recognition

The minimum video quality needed for the facial recognition algorithms are varies. It depends on how the processing in the server. According to (Korshunov & Ooi, 2011), the quality did degrade the facial recognition performance. The systems were tested and it shows

the face detection algorithm remains accurate until the critical quality point which is 20% of the original images size and for the pixel relation areas are 11%.

2.4 UMACE match filter

According to Zhu, Liao, Lei, Liu, & Li, (2007), MACE or Minimum Average Correlation Energy filter was used to minimize the average correlation energy over the image class while satisfying the linear constraint the correlation value at origin simultaneously. UMACE filter also have a better recognition rate than the other filter but lower rejection rate Maddah & Mozaffari, (2012) with 80% recognition rate rather than the other filter.

Through the research done by Rosniwati Ghafar et al. (2008), the UMACE match filtering could distinguish between awake and sleep state of a participant in electroencephalogram (EEG) signal. According to them, UMACE filter able to minimize the average correlation energy of the training image while constraining the correlation output at the origin to a specific value for each training images. The MACE filter used to reduce the side lobe after the Synthetic Discriminant Function (SDF) produced a pre-specified peak. The peak constrain can affect the results as the side lobe become larger than the controlled origin. These process give the optimal detection result thus give a good result for detection process.

Chapter 3 METHODOLOGY

3.1 Research Design

This was exploratory research for implementing face recognition process during running event. The performance of the selected method will be explored and evaluated during the study. UMACE method was selected for this study because it is easy to implement and can produce a result in short time.

3.2 Participants

The participants for this project were the 20 runners that run in Kelantan Open Run last years in children category. During the running events, the video was placed at the selected area to capture the face of a runner. However, only 3 images with fewer variations will be chosen for comparison process as training and test images.

3.3 Source of videos

The videos were captured at University Sains Malaysia Health Campus, where the Kelantan Open Run was held. The data was processed using MATLAB software installed to the personal computer.

3.4 Instruments

In this project, we were going to use 2 cameras with different specification which are Canon DSLR and SJCAM 500. Both of them were set into the highest resolution offered by both cameras. For frame per second, the DSLR only can reach up to 30 frames per second while the SJCAM500 camera can reach up to 60 frames per seconds. For the processing phase, we use Video to Picture Watermark software because it has free version and it can converts the video to picture up to 60 frames per second.

3.5 Methodology

3.5.1 Recording

Two cameras were used for recording process during the Kelantan Open Run 2015. The cameras were placed at four checkpoints for children course/route. The resolutions for the SJCAM camera was set to 1280 x 60 fps and the CANON camera used lower resolution. The camera was used for recording the video at the specific checkpoint. During the events, it was moved to the other checkpoint after all the runners passed by the checkpoints. Only two cameras were used during the recording session, one volunteer was appointed to move the camera to the next check point.

3.5.2 Pre-Processing

The video captured were converted into frames or pictures using the Video to Picture converter from Watermark free software. The videos were converted into 60 frames per second pictures in order to get more pictures of the runners. The resolutions of the pictures were changed into high definition for the filter to work efficiently.



Figure 1: Conversion of video into pictures using watermark software

The pictures then were cropped using Microsoft Paint in order to select the region of interest (ROI) because the face recognition usually detects the eye, eyebrows, and nose also mouth positions. The process was time consuming; the quality of the picture was analyzed for each person. The faces in the video were manually extracted from the converted image for further analysis. Then picture of the runner' face was classified according to the owner into 1 folder and named mask 1 to 10. The tested pictures were chosen from another checkpoint. The pictures of the runner' face must facing forward or facing the camera in

order to detect the position of four components of the face which is eyes, eyebrows, nose, and mouth.

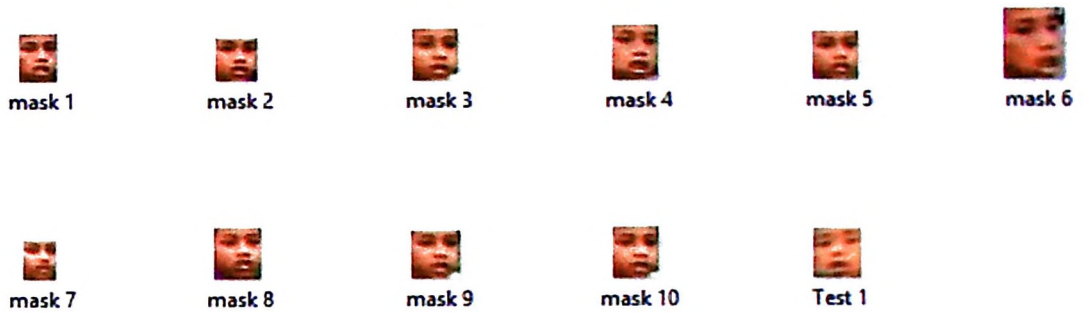


Figure 2: data set using captured video

UMACE filter algorithm was chosen for the face recognition process. The algorithm was developed using MATLAB programming language. User needs to set the number of training images for the UMACE before running the UMACE program. A database or dataset with a set of images needed to be set up for this process. The number of training images will affect the performance of UMAC filter.

3.5.3 Processing

Before starting the processing, a number of training images were selected. Training images will produce a mask for the comparison. Several numbers of training images will be checked in this research. The number of training images will be set to 2, 5 and 10 for

different process iteration. Then the images will undergo Fourier face transform, which was being utilize in the UMACE filter. The algorithm was tested using different number of training images and the data were collected and observed.

The training images will either undergo histogram equalization or not. Histogram equalization (HE) was used to enhance the contrast to adjust the intensities of the picture (Yeganeh, Ziaei, & Rezaie, 2008). The performance of UMACE filter can be improved by using processed image as training images. The image was pre-processed using specific method to improve the image quality. Histogram equalization is the common method used as a pre-processing method in image analysis. The performance of UMACE filter was compared using histogram equalization and without histogram equalization in order to choose the suitable method for the pre-processing step in the face recognition process.

3.6 Statistical Analysis

Before implementing UMACE filter to the specific problem. It is a good practice to detect the optimal criteria needed for the proposed method to produce the best performance with the highest sensitivity, specificity, and precision and accuracy percentage. In this research, we will investigate the criteria needed for the UMACE in order to perform the best recognition process using raw data from the running event.

The value that indicates the performance of the UMACE filter was Peak-to-side lobe ratio (PSR) value which is used as face recognition performance indicator. The previous

research about face recognition used the PSR value to evaluate and observe the performance of the face recognition algorithm.

$$PSR = \frac{peak - mean}{\sigma}$$

Equation 1: Peak-to-side lobe ratio

To compare the result in the table, we use sensitivity vs. specificity calculation to know the percentage of true positive and the true negative rate. The three images will be used as authentic images either in controlled or in uncontrolled environment. The authentic images count will be assessed as true positive while the impostor images that get the lower value will be count as true negative. For the true images that get a lower value will be assessed as false negative and the false images that have highest PSR value will be assessed as false negative count.

Then the percentage of sensitivity, specificity, accuracy and precision of the algorithm will be calculated using equation 2, 3, 4 and 5 respectively. Based on the calculated value, the performance of UMACE algorithm for face recognition will be evaluated.

$$\frac{True\ positive}{(true\ positive + true\ negative)} = sensitivity\ (\%)$$

Equation 2: Sensitivity of the UMACE filter

$$\frac{True\ Negative}{True\ negative + false\ positive} = specificity\ (\%)$$

Equation 3: Specificity of method

$$\frac{TP + TN}{TP + TN + FP + FN} = \text{accuracy of the method}$$

Equation 4: Accuracy of method

$$\frac{\text{true positive}}{\text{true positive} + \text{false positive}} = \text{precision of the method}$$

Equation 5: Precision of method

Chapter 4 Result

4.1 Introduction to chapter

Most of the previous method used good quality of images with small variations between the archive images. Usually large database is recommended to increase the performance of the UMACE filter. In this preliminary research, small database was used based on the running event data and a few still images was used to check the optimal criteria and performance of the proposed method.

UMACE usually used a huge database to produce the best performance in the recognition process. Because of the limitation with a small database, UMACE filter was checked with a small number of images used as a training image in this research. The performance of the UMACE was checked with 2 training images, 5 training images and 10 training images.

4.2 Two images as training images (N=2)

Table 1: PSR (peak) value when N=2 under controlled environment (without HE)

	Image 1	Image 2	Image 3
Image 1	10.2238	7.0362	6.0215
Image 2	13.2373	13.7157	9.2052
Image 3	0	0	17.0319

Table 2: Accuracy of the method when N=2 under controlled environment (without HE)

	Positive Detection	Negative Detection	
Authentic/Positive 4	3	1	Precision 75%
Impostor/Negative 5	0	5	-ve predictive 100%
	Sensitivity 38%	Specificity 17%	Accuracy 89%

The result in Table 1 showed range of PSR value for images under controlled environment that didn't undergo histogram equalization with 0 to 17.0319. If the threshold was set at a value of 10, the performance of UMACE filter will produced the value of specificity, sensitivity and accuracy as shown in Table 2. The sensitivity, specificity and accuracy of the method were 38%, 17% and 89% respectively.

Table 3: PSR (peak) value using image under controlled environment (with histogram equalization)

	Image 1	Image 2	Image 3
Image 1	11.4925	0	8.1840
Image 2	8.7693	7.9862	0
Image 3	4.6081	0	15.9520

Table 4: Accuracy of the method when N=2 under controlled environment (with HE)

	Positive Detection	Negative Detection	
Authentic/Positive 2	2	0	Precision 100%
Impostor/Negative 7	1	6	-ve predictive 83%%
	Sensitivity 25%	Specificity 100%	Accuracy 89%

When using histogram equalization to enhance the images, the range of PSR value in table 3 becomes 0 to 15.9520 for the images under controlled environment. If the threshold was set at 10, the performance of the UMACE filter will produced the measurement as shown in Table 4.. Thus the sensitivity, specificity and accuracy after enhancing the images became 25%, 100% and 89% respectively.

Table 5: PSR value when N=2 under uncontrolled environment (without HE)

	Image 1	Image 2	Image 3
Image 1	8.6764	15.7165	17.1772
Image 2	9.5284	17.1514	18.8062
Image 3	9.9147	8.6560	9.9901

Table 6: Accuracy of method when N=2 under uncontrolled environment (without HE)

	Positive Detection	Negative Detection	
Authentic/Positive 4	1	3	Precision 25%
Impostor/Negative 5	2	3	-ve predictive 60%
	Sensitivity 25%	Specificity 50%	Accuracy 44%

Table 5 showed PSR value of 8.6764 to 18.8062 under uncontrolled environment using raw images from the running event. When the threshold was set at 15, the sensitivity, specificity and accuracy of the method became 25%, 50% and 44% respectively. The value was shown in Table 6.

Table 7: PSR value for images when N=2 under uncontrolled environment (with HE)

	Image 1	Image 2	Image 3
Image 1	30.4008	31.5325	91.3870
Image 2	19.0901	42.5434	91.5641
Image 3	21.7477	0	0

Table 8: Accuracy of the method when N=2 under uncontrolled environment (with HE)

	Positive Detection	Negative Detection	
Authentic/Positive 7	2	5	Precision 33%
Impostor/Negative 2	1	1	-ve predictive 50%
	Sensitivity 67%	Specificity 20%	Accuracy 33%

The images from uncontrolled environment have lower sensitivity even after the histogram equalization. Result showed too much variation since the authentic images of the participant only score 30.4, 42.5 and 0 for image 1, 2, 3 respectively. The impostor images score higher than the authentic images in these circumstances with image 3 score 91.4 and 91.6 when compared on training images of 1 and 2 but when compared with its own images, it scored 0 while the test image of 1 score higher with 21.5. Due to high PSR value, the threshold was set to 15 thus the sensitivity of the method was 68% while the specificity became 50%. After using equation above, the accuracy become 56%. The result was shown in the Table 6.

4.3 Using 5 training images (N=5)

Table 9: PSR value for images under controlled environment when N=5 (without histogram equalization)

	Image 1	Image 2	Image 3
Image 1	13.7441	5.5829	7.5830
Image 2	14.0535	13.3052	5.1460
Image 3	13.3303	9.0267	19.8383

Table 10: Accuracy of the method when N=5 under controlled environment (without HE)

	Positive Detection	Negative Detection	
Authentic/Positive 5	3	2	Precision 60%
Impostor/Negative 4	0	4	-ve predictive 100%
	Sensitivity 43%	Specificity 66%	Accuracy 78%

When five numbers of images under controlled environment used for training images, Image 1 and image 3 produced a positive result with the authentic images score highest with 13.7441 and 19.8383 respectively. However, image 2 didn't get a good result with lower PSR value on authentic images than image 2 with 13.3052 without histogram equalization. The

sensitivity and specificity of the method were 43% and 66% respectively. The threshold was set at 10 and the accuracy of the method was 78% as shown in Table 10.

Table 11: PSR value when N=5 under controlled environment (with HE)

	Image 1	Image 2	Image 3
Image 1	13.066	5.583	7.583
Image 2	14.504	13.305	4.131
Image 3	8.9901	6.0725	14.8794

Table 12: Accuracy of the method when N=5 under controlled environment (with HE)

	Positive Detection	Negative Detection	
Authentic/Positive 4	3	1	Precision 75%
Impostor/Negative 5	0	5	-ve predictive 100%
	Sensitivity 38%	Specificity 83%	Accuracy 89%

Same thing happens when the images were enhanced using histogram equalization, the image 1 and 3 produce a good result with 13.066 and 14.8794 respectively on the authentic images while image 2 get lower score for the authentic images but higher PSR value when

compared with image 1. The threshold for the images under controlled environment was set at 10. Thus the sensitivity of the method was 67% and the specificity of the method was 83% as shown in table 12.

Table 13: PSR value when N=5 for images under uncontrolled environment (without HE)

	Image 1	Image 2	Image 3
Image 1	17.8235	28.7751	101.8067
Image 2	0	28.0542	84.4873
Image 3	13.9182	20.6950	13.6678

Table 14: Accuracy of the method when N=5 under uncontrolled environment (without HE)

	Positive Detection	Negative Detection	
Authentic/Positive 5	1	4	Precision 20%
Impostor/Negative 4	2	2	Negative predictive 50%
	Sensitivity 33%	Specificity 33%	Accuracy 33%

For the images under uncontrolled environment used raw data from running event and at didn't use histogram equalization as pre-processing method, none of the authentic test images score high PSR value. The rank of the value 17.8234 (image 1), 28.7751 (image 2) and 13.6678

(image 3). Image 3 that score highest PSR value on the previous test images also score the lowest when compared with its own image. Thus there is none of true positive value and 3 true negative values which mean the sensitivity of the method was 0% and the specificity of the method was 50% as shown in table 14.

Table 15: PSR value when N=5 for images under uncontrolled environment (with HE)

	Image 1	Image 2	Image 3
Image 1	30.5486	38.6159	72.9152
Image 2	0	38.1699	71.7795
Image 3	0	13.2607	20.7476

Table 16: Accuracy of the method when N=5 for image under uncontrolled environment (with HE)

	Positive Detection	Negative Detection	
Authentic/Positive 4	3	1	Precision 75%
Impostor/Negative 5	0	5	Negative predictive 100%
	Sensitivity 38%	Specificity 83%	Accuracy 89%

When histogram equalization applied, the image 1 and 2 still score lower for the authentic images with 30.5486 and 38.1699 respectively. Image 3 produced a better result with high PSR