

**USAGE of PHOTOGRAMMETRIC METHODS for DETECTION
SKIN DISORDERS and THEIR EVALUATION**

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Programme : Geomatics Engineering

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**CİLT HASTALIKLARININ
BELİRLENMESİNDE ve DEĞERLENDİRİLMESİNDE
FOTOGRAMETRİK YÖNTEMLERİN KULLANIMI**

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FOREWORD

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June 2011

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ABBREVIATIONS

AV	: Aperture Value
ASPRS	: American Society of Photogrammetry and Remote Sensing
AUTh	: Aristotle University of Thessaloniki
AWB	: Automatic White Balance
FFT	: Fast Fourier Transform
SS	: Shutter Speed
WB	: White Balance

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USAGE OF PHOTOGRAMMETRIC METHODS FOR THE DETECTION SKIN DISORDERS AND THEIR EVALUATION

SUMMARY

Abnormalities on skin may vary from simple acne to painful wounds which affect a person's life quality. Detection of this kind of disorders in early stages and following the evaluation of abnormalities are of high importance. At that stage, photogrammetry becomes a part of this concern with its ability to provide geometrically highly accurate visual data without physical contact.

ASPRS defines photogrammetry as *“the art, science and technology of obtaining reliable information about physical objects and the environment, through processes of recording, measuring, and interpreting images on photographic images and patterns of recorded radiant electromagnetic energy and other phenomena”*. Photogrammetry, which has been used for firstly topographic purposes, in virtue of terrestrial photogrammetry became useful technique in non-topographic applications also (Wolf et al.,2000). Moreover the extension of usage of photogrammetry, in paralel with the development in technology, analogue photographs are replaced with digital images and besides digital image processing techniques, it provides modification of digital images by using filters, registration processes etc. Moreover photogrammetry (using same coordinate system by registration of images) can serve as a tool for the comparison of temporal imaging data.

The aim of this thesis is to examine some digital image processing techniques and filters which might be useful to determine skin disorders by using photogrammetric method and determine some environmental conditions, most appropriate camera settings like ISO Speed, Shutter Speed, Aperture Value, White Balance etc. to acquire images in order to have most suitable appearance of interested object and then, evaluating data with the use of computer aided programs.

It should be noted that, some of the methods mentioned below in the thesis are newly used for medical purposes and are still on experimental level and further investigations with deeper examinations are necessary.

CİLT HASTALIKLARININ BELİRLENMESİNDE ve DEĞERLENDİRİLMESİNDE FOTOGRAMETRİK YÖNTEMLERİN KULLANIMI

ÖZET

Derideki anormallikler basit aknelere kadar kişinin yaşam kalitesini etkileyen acı verici yaralara kadar değişkenlik gösterebilir. Bu tür bozuklukların erken dönemde teşhis edilmesi ve gelişiminin izlenmesi yüksek derecede önem taşımaktadır. Bu aşamada, fotogrametri fiziksel temasta bulunmadan yüksek geometrik doğruluklu görsel veri elde edebilme özelliğiyle bu konunun bir parçası olmaktadır.

Fotogrametri, ASPRS tarafından “ Fiziksel objeler ve çevre hakkında kayıt, ölçme ve yorumlama yoluyla fotoğraflardan ve diğer görsel materyaller üzerinde güvenilir bilgi etme sanatı, bilimi ve teknolojisi” olarak tanımlanmaktadır. İlk olarak topografik amaçlarla kullanılmaya başlanmış olan fotogrametri yersel fotogrametri ile birlikte topografik olmayan uygulamalarda da önemli bir teknik haline gelmiştir (Wolf et al., 2000). Fotogrametrinin kullanım alanlarının genişlemesinin yanında, teknolojiye gelişmelerle paralel olarak, analog fotoğrafların yerini dijital görüntüler almakta ve bu durum dijital görüntü işleme teknikleri ile birlikte görüntüler üzerinde modifikasyon yapılabilmesine olanak sağlamaktadır. Bunun yanında, resimlerin birbirine geometrik olarak dönüştürülerek aynı koordinat sistemine getirilebilmesi özelliği ile fotogrametri, aynı objeye ait farklı zamanlarda elde edilen verilerin karşılaştırılmasına olanak vermektedir.

Bu tezin amacı, fotogrametrik yöntemler kullanılarak cilt hastalıklarının belirlenmesinde yararlı olabilecek dijital görüntü işleme teknikleri ve bazı filtrelerin araştırılması ve ilgilenilen objenin amaca en uygun görüntüsünün elde edilebilmesi için çevresel koşullar ile ISO değeri, diyafram açıklığı, objektif hızı, görüntünün beyaz dengesi gibi kamera ayarlarının belirlenmesi ve sonrasında bilgisayar destekli programlarla değerlendirilmesidir.

Özellikle dikkate alınmalıdır ki bu çalışma içerisinde yer alan bazı yöntemler tıbbi amaçlara yönelik olarak yeni kullanılmaya başlanmış ve hala deneysel aşamada bulunmaktadır. Bu nedenle daha ileri düzeyde araştırmalar ve daha derin, uzun soluklu deneyler yapılması gerekmektedir.

1. INTRODUCTION

Abnormalities on skin may vary from simple acne to painful wounds which affect a person's life quality. Detection of this kind of disorders in early stages and following the evaluation of abnormalities are of high importance. At that stage, photogrammetry becomes a part of this concern with its ability to provide geometrically highly accurate visual data without physical contact. In addition with digital image processing techniques, it enables the modification of digital images by using filters, registration processes etc. Moreover photogrammetry (using same coordinate system by registration of images) can serve as a tool for the comparison of temporal imaging data.

1.1. Motivation

Photogrammetry, which has been used for firstly topographic purposes, in virtue of tereestrial photogrammetry became useful technique in non-topographic applications also. Aircraft manufacture, forestry, telecommunication, archeology, architecture, geology, engineering, criminology, medicine and dentistry can be counted in that concern (Wolf et al.,2000). When compared with the other fields, medical photogrammetry is quite new area for photogrammetric applications but despite the newness, it has many sub-fields X-Ray photogrammetry, 3D modelling from CT and MR images, determination and observation of physical disorders like scoliosis, or wound measurement even image guided surgery.

Medical photogrammetry as well as being new it also requiers different and generally unique system designs for every different sub-area. This challenging feature generates the motivation of this thesis as a start.

1.2. Aim of the Thesis

The aim of this thesis is to determine some conditions such as lighting conditions, most appropriate camera settings like ISO Speed, Shutter Speed, Aperture Value, White Balance etc. to acquire images that yield the most natural appearance and then, evaluating data by using digital image processing techniques to extract the most suitable information, detection of disorders and observation of their evaluation with the use of computer aided programs.

Improvements on technological area pave the way for photogrammetry to be used in different subjects and applications. Medical field is one of the freshest but promising scope. It should be noted that, some of the methods mentioned below in the thesis are newly used for medical purposes and are still on experimental level and further investigations with deeper examinations are necessary.

2. PROPOSED METHODOLOGY

The detection of skin disorders and their evaluation is divided into some basic steps which are

1. **Determining the conditions for most real like images:** This step consists of experiments using different camera conditions in order to decide the most appropriate criteria that satisfy the needs of the work.
2. **Image enhancement:** Image enhancement is the step for neutralizing the illumination effects by using homomorphic filter, thus obtaining light independent conditions.
3. **Registration:** It is the process needed to compare (pixel by pixel) the temporal images.
4. **Image Processing by Filters:** It includes different applications of filtering to reveal automatically the detection of skin disorders.
5. **Quantitative Analysis:** Determining the true space that the scar covers and gives to the decision maker the tool measure it. This step is processed by using two separate tools in Photoshop (which are the magic wand and the magnetic lasso tool).

3. DETERMINING THE CONDITIONS FOR THE MOST REAL-LIKE IMAGES

In accordance with this purpose, different type of skin artifacts was taken under consideration with different camera parameters in order to acquire the most realistic images. According to Boersma (1998), if the camera is very sensitive to light, very strong illumination might not be necessary; on the other hand, common lighting should respond the need of providing sufficient depth of field. White fluorescent light was used in the experimental stage. Other light sources like monochromatic light were considered to be used but due to technical reasons only white fluorescent light source was used during the experiments. Because of this reason, different type of skin artifacts acquired from internet were used to examine the result of derived criteria, parameters and image processing stages.

As a primary test, a set of examination was run in order to consider which camera parameters provide most real-like vision. A colorful paper was attached on the wall to take snapshots. 82 images were taken in different shutter speed, aperture mode, metering mode, ISO Speed and White balance specifications. After the evaluation of images, the criteria below were determined the most suitable to collect the most natural images.

- ISO Speed: 400
- Shutter Speed: 2”5
- Aperture Value: 32
- Metering Mode: Evaluative
- White Balance: AWB (Automatic White Balance)

Figure 3.1 shows different test snapshots with different criteria.



(a)



(b)



(c)



(d)

Figure 3.1: Test snapshots with different parameters: (a) *SS: 2", AV:32, WB: AWB*; (b) *SS: 2"5, AV:: 32, WB: AWB*; (c) *SS: 2", AV: 32, WB: White Fluorescent*; (d) *SS: 2"5, AV: 32, WB: White Fluorescent*

All snapshots were acquired in Aristotle University of Thessaloniki Laboratory with Canon EOS Digital Rebel XT_i Camera at 55mm focal length, no flash, one-shot AF Mode. All the images were stored as Jpeg format at large image size (3888 x 2592). Other camera specifications can be found at Canon Digital Rebel XT_i White Paper.

After, conditions were tested with colorful irrelevant image to the medical application; another two different test images that depict the same skin disorder at different sizes were also acquired. Figure 3.2 shows two different shutter speed conditions on "Test Image#1".



(a)



(b)

Figure 3.2: Medical test images#1 (a) SS: 2"5, AV:32, WB: AWB; (b) S S: 2", AV: 32, WB: AWB;

4. IMAGE ENHANCEMENT

Since the illumination condition has the major affect on the appearance of the subject, light conditions need to be standardized in order to use the method in every environment. For this reason, in order to reduce the effect of the illumination, homomorphic filter was applied to images. It is a multiplicative filter that affects a lot with the images' intensity. Homomorphic filter is based on the idea that optical images have two components which are luminance and reflectance. Poor contrast images can be enhanced by straining the light source and increasing the reflectance at the same time (Al-Amri et al., 2010).

Since the Fourier Transform is suitable to be used when the noise can be modeled as additive term to the original image values, defects like uneven lighting, needs to be modeled as multiplicative term. As a combination of illumination and reflectance an image can be modeled below (Matthys, 2001).

$$f(x, y) = i(x, y) . r(x, y) \quad (1)$$

Adelmann (1998) states that frequency-domain filtering of images serves as both multilateral and strong tool but, illumination and reflectance components of an image can not be operated differently in the frequency domain, because as seen in equation1 above the two mentioned components are in multiplicative form and not seperable. In order to apply Fourier Transform, multiplicative equation must be converted to an additive form.

For this aim, logarithmic operation must be applied as indicated below.

$$\ln [f(x, y)] = \ln[i(x, y)] + \ln [r(x, y)] \quad (2)$$

Taking the FFT of both sides of the equation it leads to the formula (Matthys,2001):

$$F'(n, m) = I'(n, m) + R'(n, m) \quad (3)$$

- where n and m are spatial frequencies in the x and y directions

Applying a suitable Fourier filter function $H(n,m)$:

$$S(n,m) = F'H = I'H + R'H \quad (4)$$

Taking the inverse of FFT:

$$s(x,y) = \ln[r(x,y)] + \ln[i(x,y)] \quad (5)$$

Finally, taking the exponential of both sides:

$$g(x,y) = \exp[s(x,y)] = r(x,y) \quad (6)$$

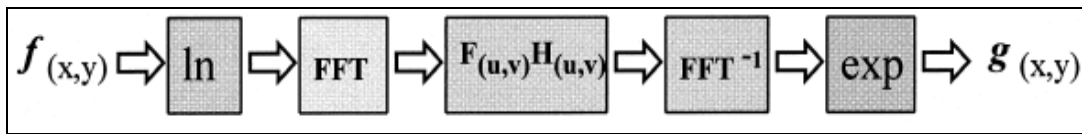


Figure 4.1: Flowchart of homomorphic filter (Adelmann, 1998).

Homomorphic filter was applied with “Astra Image 3.0 Pro” Software. Figure 4.2 shows the homomorphic filter applied with Astra Image 3.0 Pro with original data

As seen from the figure 4.2, homomorphic filter provides clearer image around skin artifact.



(a) Original Test Image#1



(b) Homomorphic Filtered Image: *RGB strength 1.50*

Figure 4.2: Homomorphic filter applied to test image#1



(c) Homomorphic Filtered Image: *RGB strength 2.00*



(d) Homomorphic Filtered Image: *Luminance strength 1.50*

Figure 4.2 (contd.): Homomorphic filter applied to test image#1

Different strength conditions were tested and it was decided there is no significant difference between values of 1.50 to 2.00, on the other hand RGB and Luminance condition used during the filter reveals different effects. Luminance provides closer visualization to the original image but using RGB values applies biggest contrast around the disorder area. Thus, it is considered that this enables to discriminate the differences between the scar and the normal skin more easily.

As a second consideration of criteria, exposure compensations were tested and homomorphic filter was also applied to them. As a result of the comparison, changing exposure levels does not affect images dramatically especially after applying the homomorphic filter. Figure 4.3 shows test image#1 with “0” exposures and “+2” exposure and their filtered images. Minus exposure compensation makes images darker so it is not a good idea to be used.

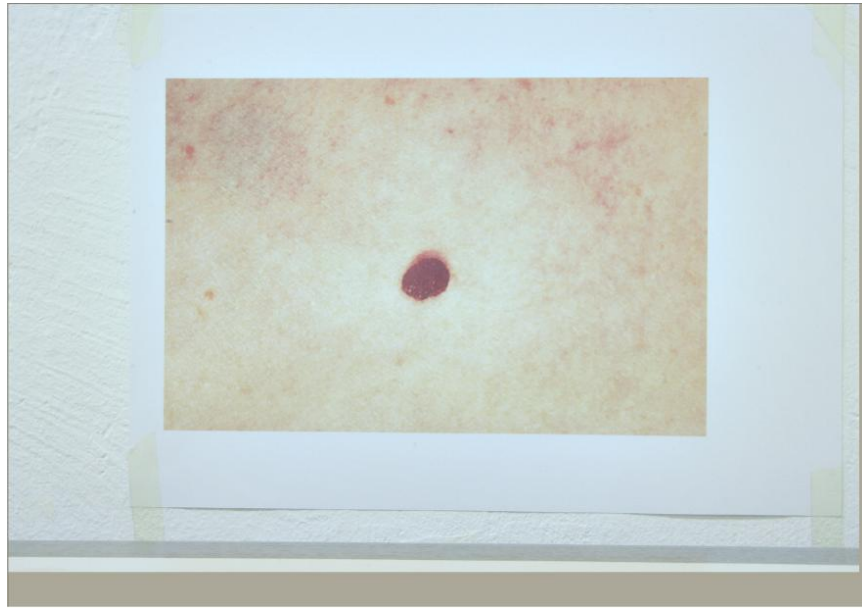


(a) Original Test Image#1 *Exposure Compensation: 0*



(b) Test Image#1 *Exposure Compensation: +2*

Figure 4.3: Different exposure compensations



(c) Homomorphic Filtered Original Test Image#1 Exposure Compensation: 0



(d) Homomorphic Filtered Test Image#1 Exposure Compensation: +2

Figure 4.3 (contd.): Different exposure compensations

5. REGISTRATION

Evaluation of the disease, growth or reduce of its size can be detected only if they are both in the same coordinate system. In order to provide the same coordinate system for both images “image to image” registration needs to be applied. In this project as first step, “Test Image#1” was accepted as base image and “Test Image#2” was warped. Registration process was run with two different program, are ENVI 4.3 and MATLAB. Original images and homomorphic filtered images were taken into consideration during the registration process. Filtered image showed better result to enable to choose Ground Control Points (GCPs) in ENVI 4.3. The problem in the registration is that registered image could not be saved in the same size as of the original one. So it revealed another problem while comparing them in Photoshop for further examinations. This problem was overcome by using “Autodesk Raster Design” software in order to crop the images into the same size. Another problem is that, ENVI 4.3 changes the colors on the images during visualization and because of that it was decided not to be used as registration tool. ENVI is a useful tool for lots of applications however; in this kind of study it does not easy to compensate the expected results.

In order to be able to perform arithmetic (and other comparing) operations between the pixels in two images, there should be available an automatic process to refer them in the same ground space. The solution to this problem lies beyond the targets of the current thesis and a generic settlement is not provided¹. However, in the current thesis a couple of time variant images should be referred to each other, thus they were registered manually using the Autodesk® Raster Design software. The software is freely available to all the academic higher educational institutes (<http://students.autodesk.com>) and the latest version 2010 has been used.

¹ There are many algorithms that might be used to perform a registration between image. The most commonly used is the SIFT (Scale Invariant Feature Transform) and its variation that has been used with grate success in the creation of panoramic images. For more details please follow the references (Lowe, Meng).

During the registration process, the one of the images is left unchanged while the other is aligned using a triplet of very well defined points visible also to the original one. The scale, shift and rotation of the second image are applied and a resampled image is generated. A common rectangle area is used to crop the two images in the same ground space (using the same ground resolution) and the comparing algorithms are applied to extract the healing progress of the tissue.

6. IMAGE PROCESSING BY FILTERS

As a main purpose of the project, skin disorders, basically scars are tried to be extracted automatically from healthy skin and observe their evaluation if they are growing or healing by using some filters. For this aim, the best visualization is considered to be black and white images. Adobe Photoshop 7.0 was used as image processing software. All the filters were applied on both homomorphically filtered “Test Image#1” and “Test Image#2”

6.1. Photocopy – Trace Contour

Photocopy filter, which is under the **Sketch** section in Photoshop Menu tend to copy large areas of darkness on the original image around the edges and the other areas are drawn back to either solid black or white (Adobe Photoshop Help Center). Photocopy filter has two criteria these are detail and darkness.

- **Detail:** It refers to how much detail in the original image will be filtered.
- **Darkness:** It refers to how dark the details will be (Yousif, 2005)

Trace Contour filter that lies under “Stylize” section in Photoshop Menu uses transitions of major brightness areas in image and highlights them in order to produce lines similar to contours in a map. This filter has two settings, edge option and level.

- **Edge Option:** Lower edge outlines areas where the color values of pixels fall below the specified level and upper edge outlines areas where the color values fall above (Adobe Photoshop Help Center).
- **Level:** It can take a value between 0 and 255 and it indicates the threshold for the evaluation of tonal values in the image.

Figure 6.1 shows images with different detail and darkness values applied on homomorphically filtered “Test Image#1”.

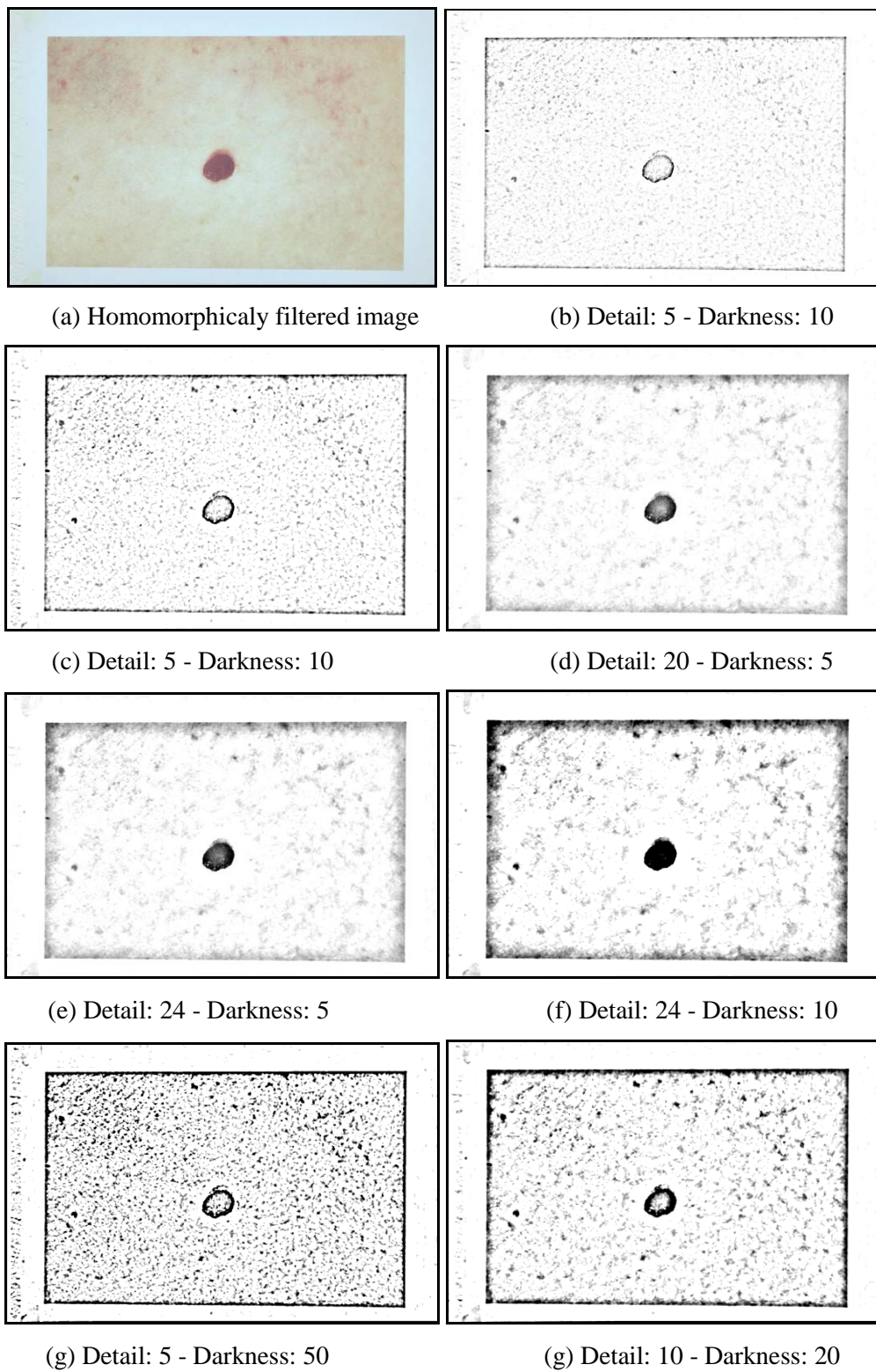
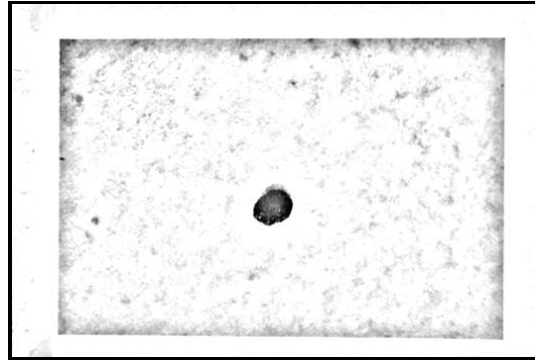


Figure 6.1: Different photocopy filter criteria applied on homomorphically filtered “Test Image#1”

Trace contour filter was applied also on different photocopy filtered images. The following sections show experiments on “Test Image#1”

6.1.1. Image 1: Homomorphically Filtered Test Image#1

- **Photocopy:** Detail: 24 – Darkness:5
- **Trace Contour:** Level, Edge Lower:128



(a) Photocopy - Detail: 24 - Darkness: 5



(b) Trace Contour - Level, Edge lower = 128



(c)

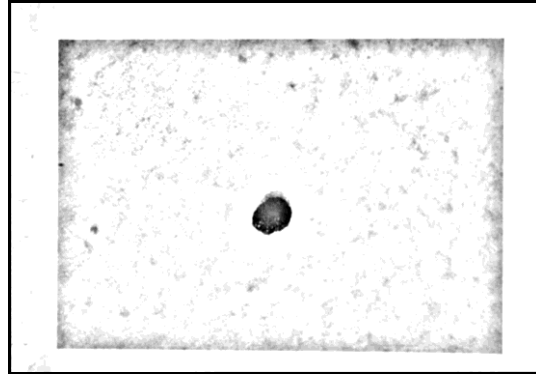
(d)

(e)

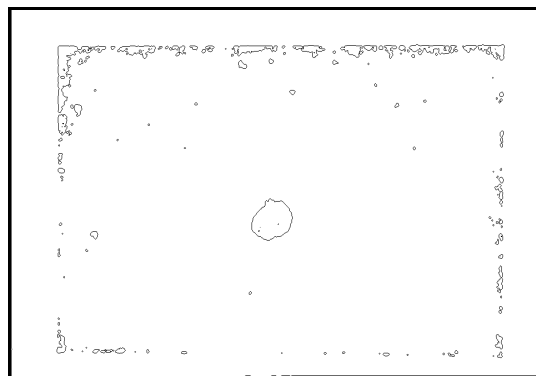
Figure 6.2: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

6.1.2. Image 2: Homomorphically Filtered Test Image#1

- **Photocopy:** Detail: 24 - Darkness: 5
- **Trace Contour:** Level, Edge Lower: 170



(a) Photocopy - Detail: 24 - Darkness: 5



(b) Trace Contour - Level, Edge lower = 170

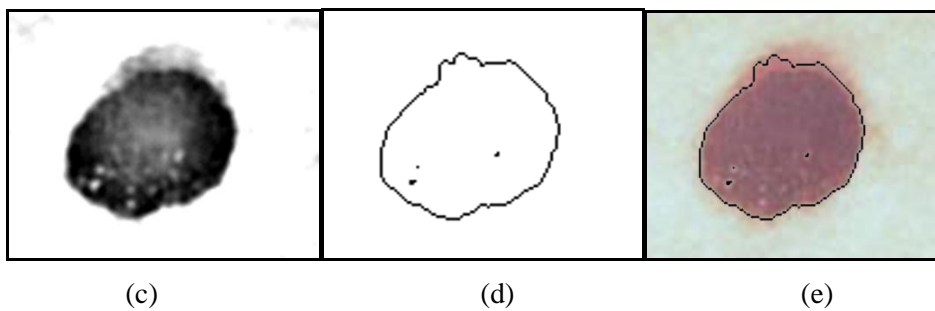
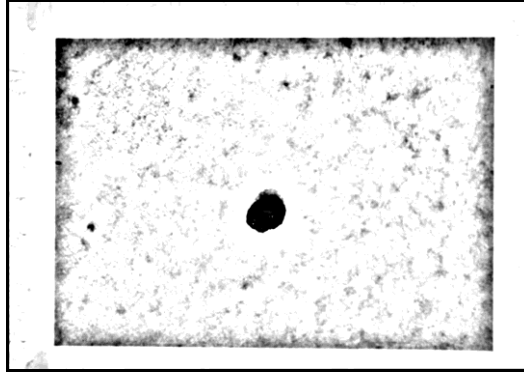


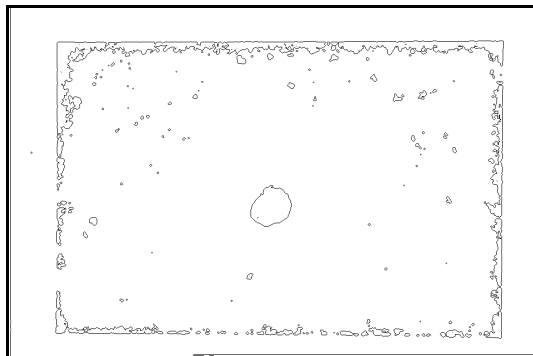
Figure 6.3: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

6.1.3. Image 3: Homomorphically Filtered Test Image#1

- **Photocopy:** Detail: 24 - Darkness:10
- **Trace Contour:** Level, Edge Lower:128



(a) Photocopy - Detail: 24 - Darkness: 10



(b) Trace Contour - Level, Edge lower = 128

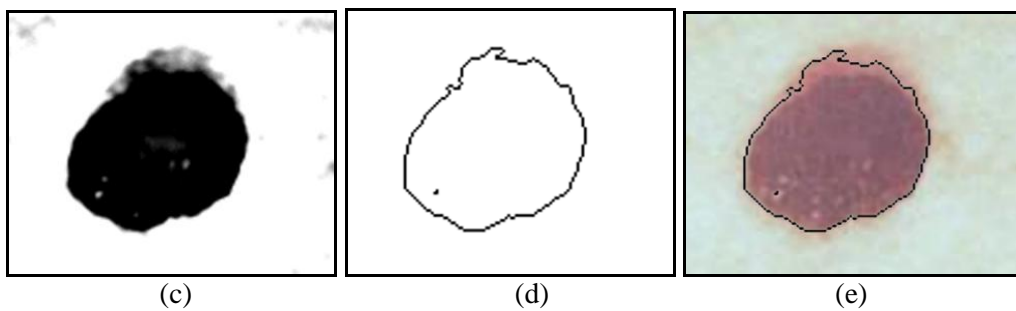
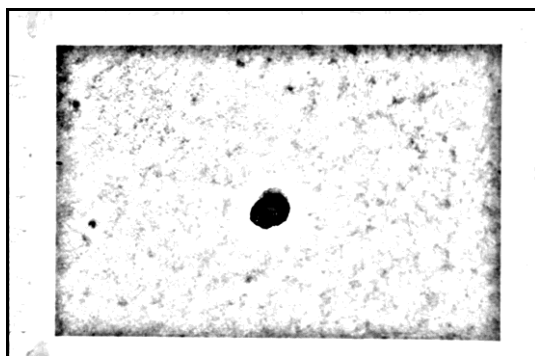


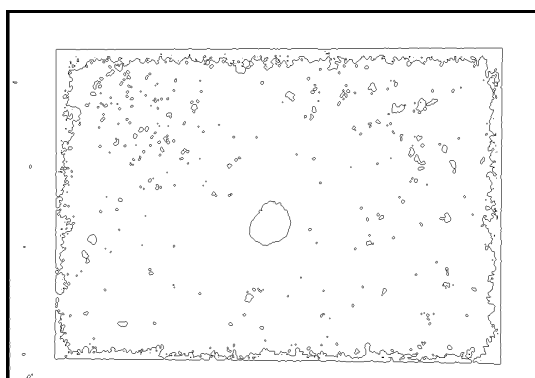
Figure 6.4: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

6.1.4. Image 4: Homomorphically Filtered Test Image#1

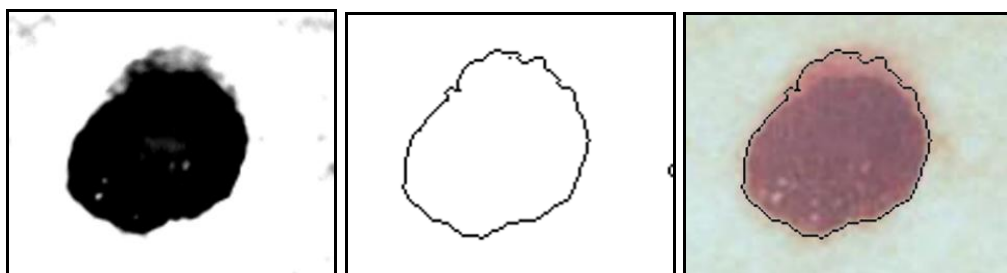
- **Photocopy:** Detail: 24 - Darkness:10
- **Trace Contour:** Level, Edge Lower:170



(d) Photocopy - Detail: 24 - Darkness: 10



(e) Trace Contour - Level, Edge lower = 170



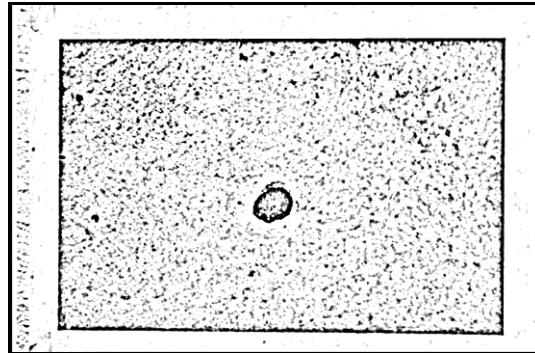
(c)

(d)

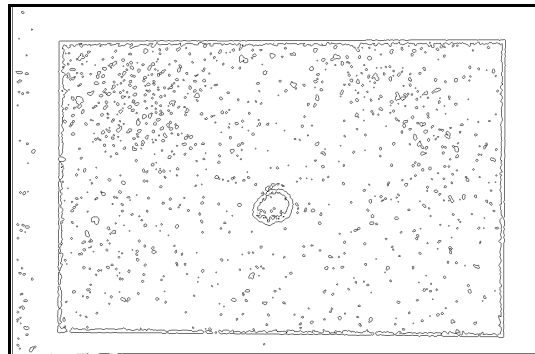
(e)

Figure 6.5: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

It was observed that large darkness values like 50 requires smaller lower edge values like 10 in order to acquire better results. The images which yield this result can be seen in Figure 6.6 below.



(a) Photocopy - Detail: 5 - Darkness: 50

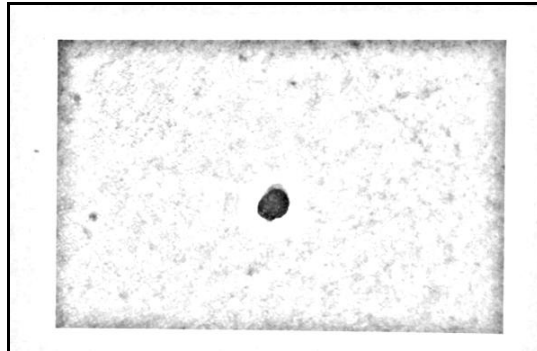


(b) Trace Contour - Level, Edge lower = 10

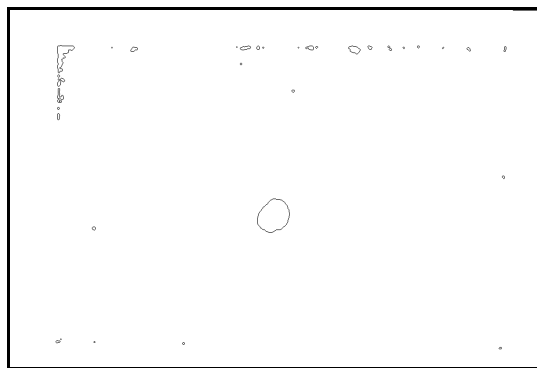
Figure 6.6: Trace Contour filter over high darkness value in photocopy filter.

6.1.5. Image 5: Homomorphically Test image#2

- **Photocopy:** Detail: 24 - Darkness:5
- **Trace Contour:** Level, Edge Lower:128



(a) Photocopy - Detail: 24 - Darkness: 5



(b) Trace Contour - Level, Edge Lower: 128

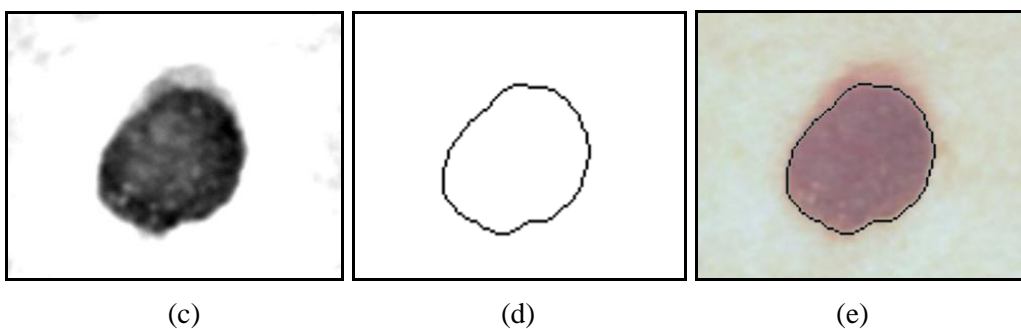
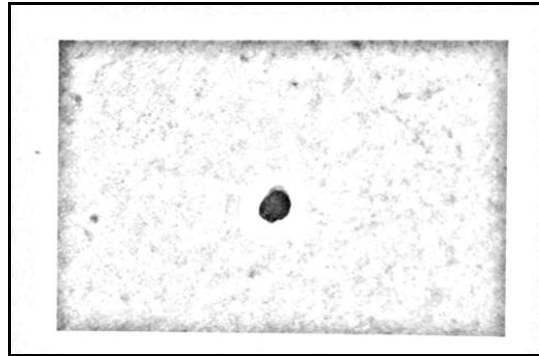


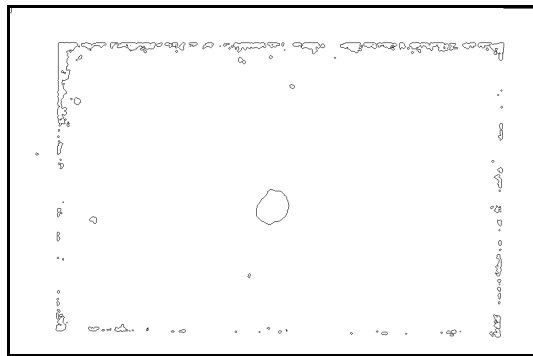
Figure 6.7: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

6.1.6. Image 6: Homomorphically Filtered image#2

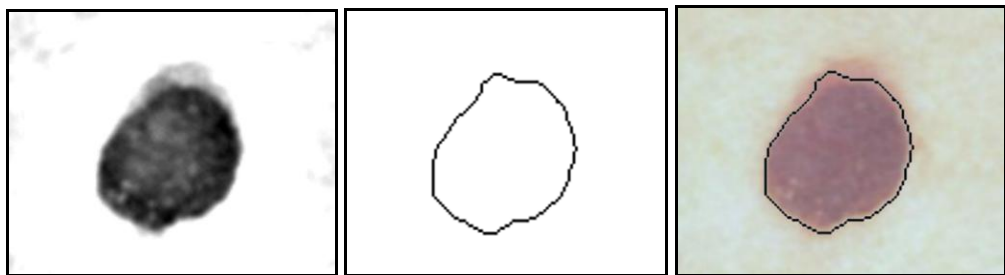
- **Photocopy:** Detail: 24 - Darkness:5
- **Trace Contour:** Level, Edge Lower:170



(a) Photocopy - Detail: 24 - Darkness: 5



(b) Trace Contour - Level, Edge Lower: 170



(c)

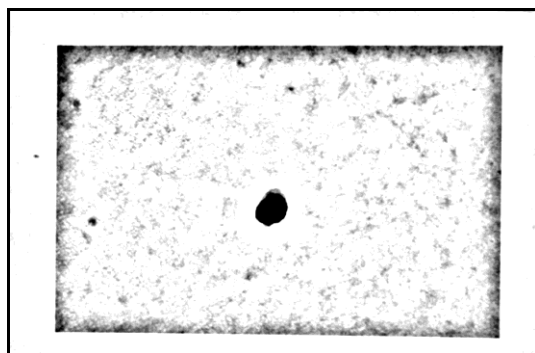
(d)

(e)

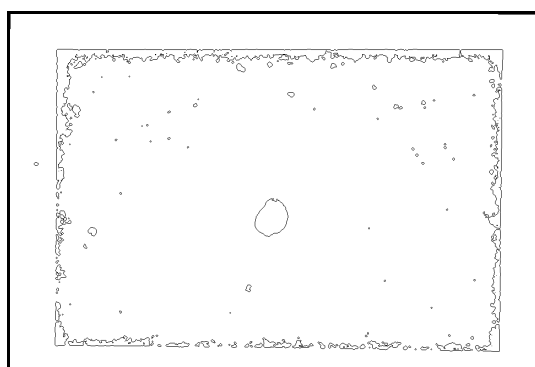
Figure 6.8: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

6.1.7. Image 7: Homomorphically Filtered image#2

- **Photocopy:** Detail: 24 - Darkness:10
- **Trace Contour:** Level, Edge Lower:128



(a) Photocopy - Detail: 24 - Darkness: 10



(b) Trace Contour - Level, Edge Lower: 128

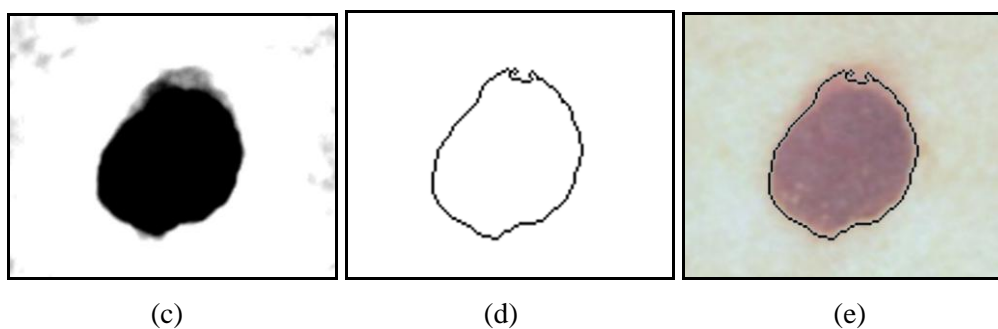
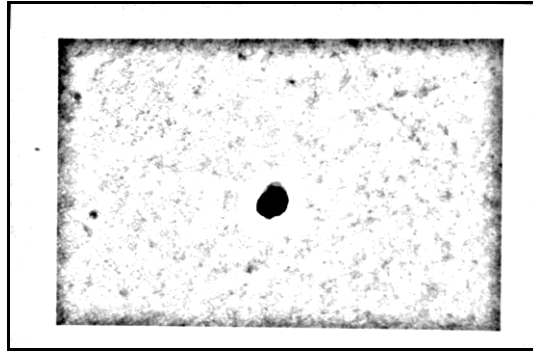


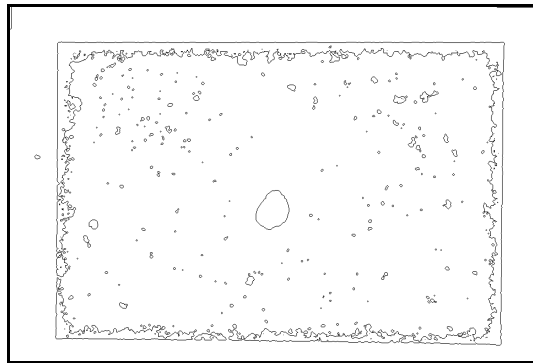
Figure 6.9: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

6.1.8. Image 8: Homomorphically Filtered image#2

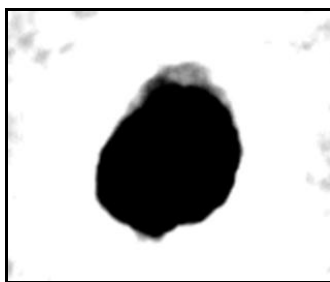
- **Photocopy:** Detail: 24 - Darkness: 10
- **Trace Contour:** Level, Edge Lower: 170



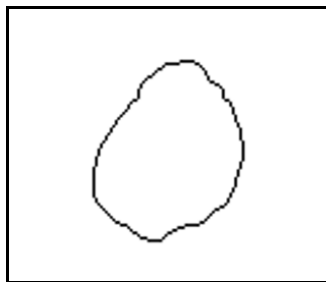
(a) Photocopy - Detail: 24 - Darkness: 10



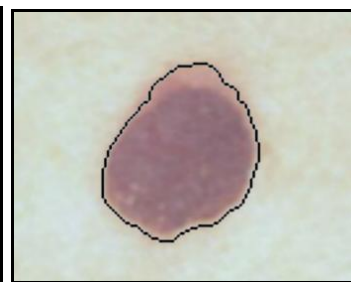
(b) Trace Contour - Level, Edge Lower: 170



(c)



(d)



(e)

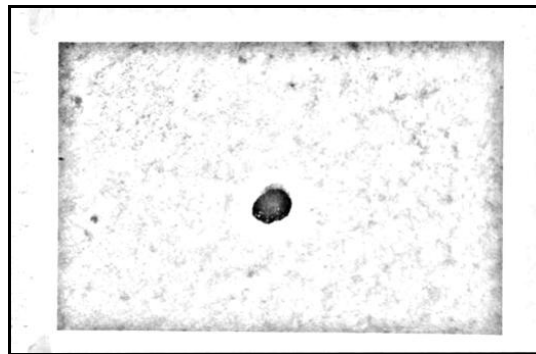
Figure 6.10: (c) Photocopy filter, (d) Trace Contour filter, (e) Trace Contour over Original Image

6.2. Photocopy - Threshold

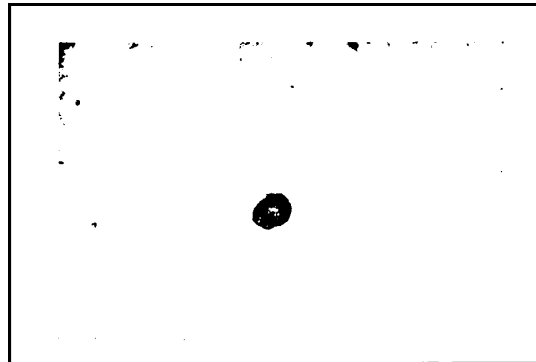
Threshold level defines the value that all the pixels lower than this value are converted to black colour and all pixels higher than threshold are converted to white colour. The value of threshold level is inversely proportional to the darkness as the parameter of photocopy filter (Adobe Photoshop Help Center).

6.2.1. Image 9: Homomorphically Filtered Test Image#1

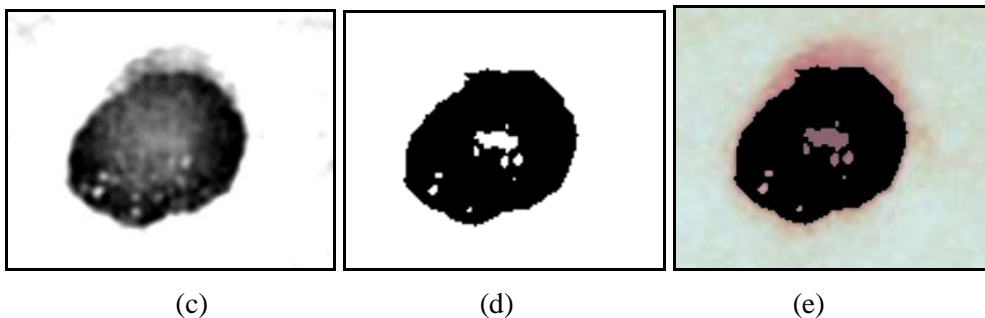
- **Photocopy:** Detail: 24 - Darkness: 5
- **Threshold:** Level: 128



(a) Photocopy-Detail: 24 - Darkness: 5



(b) Threshold level: 128



(c)

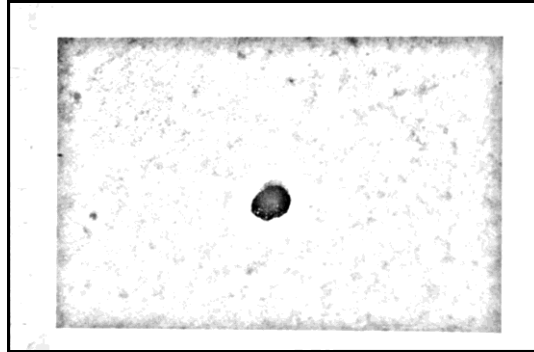
(d)

(e)

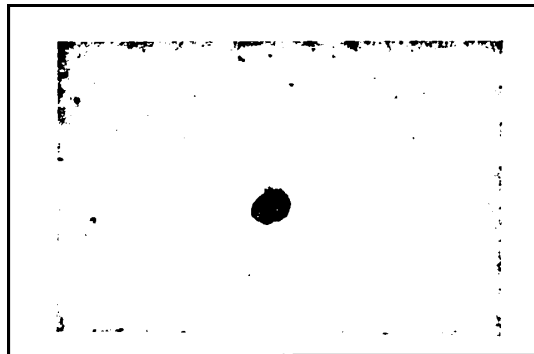
Figure 6.11: (c) Photocopy filter, (d) Threshold, (e) Threshold over Original Image

6.2.2. Image 10: Homomorphically Filtered Test Image#1

- **Photocopy:** Detail: 24 - Darkness: 5
- **Threshold:** Level: 165



(a) Photocopy-Detail: 24 - Darkness: 5



(b) Threshold level: 165



(c)

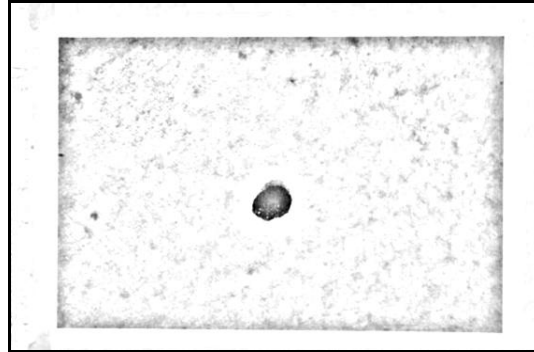
(d)

(e)

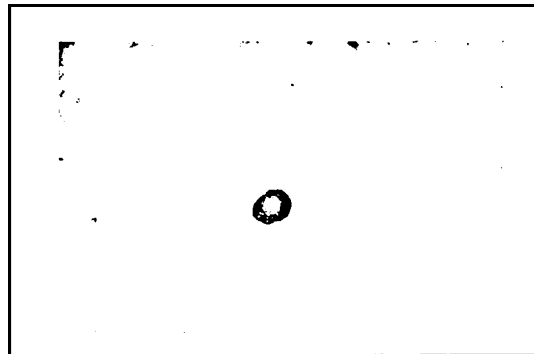
Figure 6.12: (c) Photocopy filter, (d) Threshold, (e) Threshold over Original Image

6.2.3. Image 11: Homomorphically Filtered Test Image#1

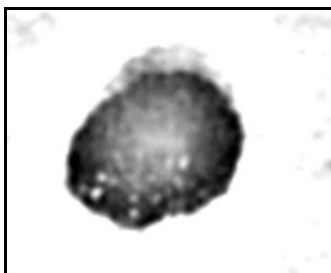
- **Photocopy:** Detail: 20 - Darkness: 5
- **Threshold:** Level: 128



(a) Photocopy-Detail: 20 - Darkness: 5



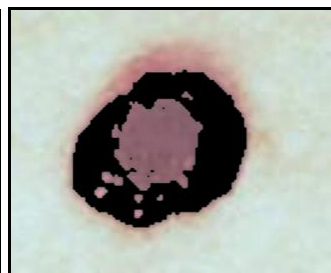
(b) Threshold level: 128



(c)



(d)

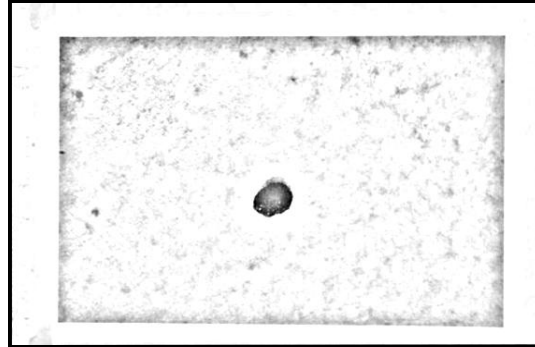


(e)

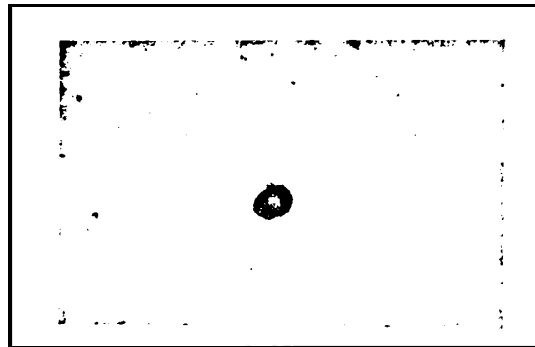
Figure 6.13: (c) Photocopy filter, (d) Threshold, (e) Threshold over Original Image

6.2.4. Image 12: Homomorphically Filtered Test Image#1

- **Photocopy:** Detail: 20 - Darkness: 5
- **Threshold:** Level: 165



(a) Photocopy-Detail: 20 - Darkness: 5



(b) Threshold level: 165

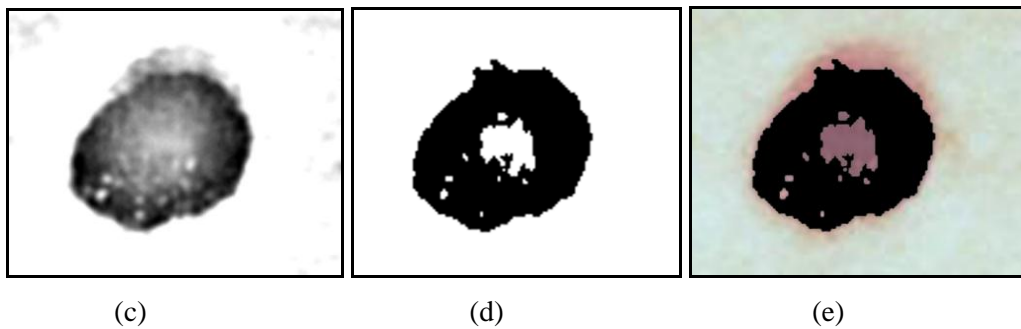
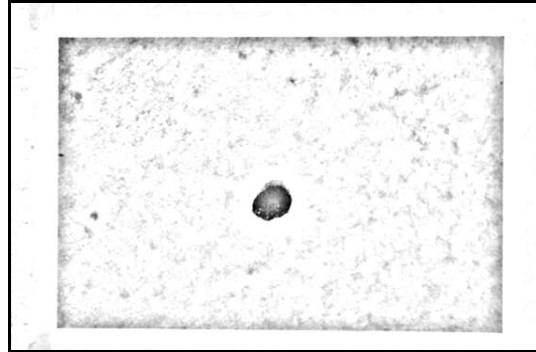


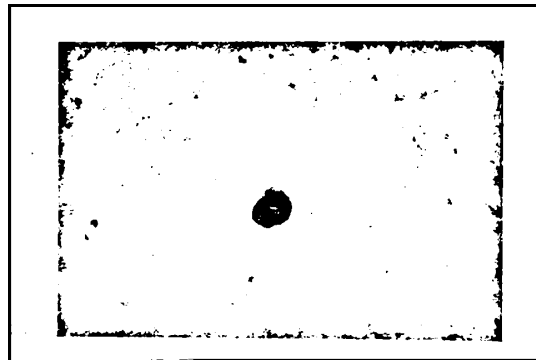
Figure 6.14: (c) Photocopy filter, (d) Threshold,
(e) Threshold over Original Image

6.2.5. Image 13: Homomorphically Filtered Test Image#1

- **Photocopy:** Detail: 20 - Darkness: 5
- **Threshold:** Level: 200



(a) Photocopy-Detail: 20 - Darkness: 5



(b) Threshold level: 200

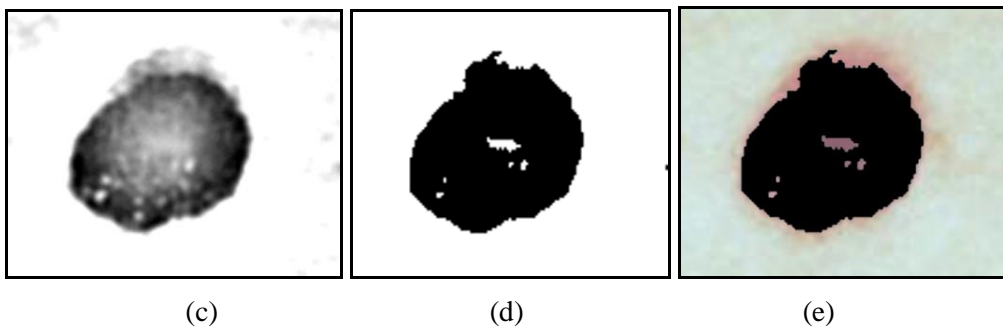
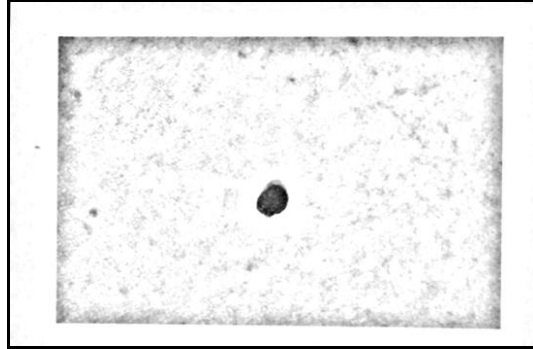


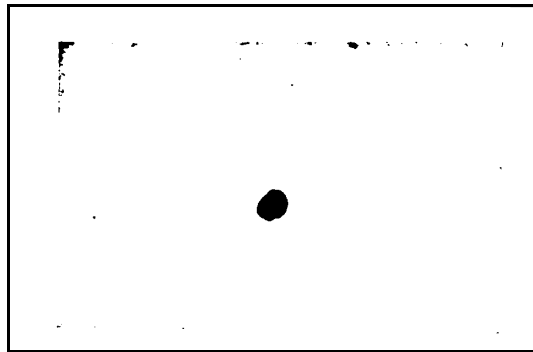
Figure 6.15: (c) Photocopy filter, (d) Threshold, (e) Threshold over Original Image

6.2.6. Image 14: Homomorphically Filtered Image#2

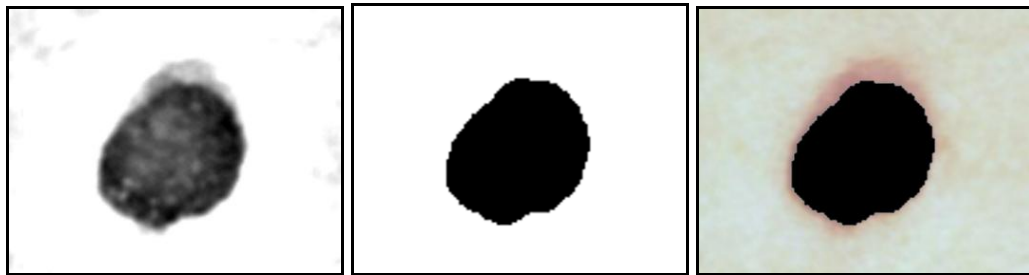
- **Photocopy:** Detail: 24 - Darkness: 5
- **Threshold:** Level: 128



(a) Photocopy-Detail: 24 - Darkness: 5



(b) Threshold: 128



(c)

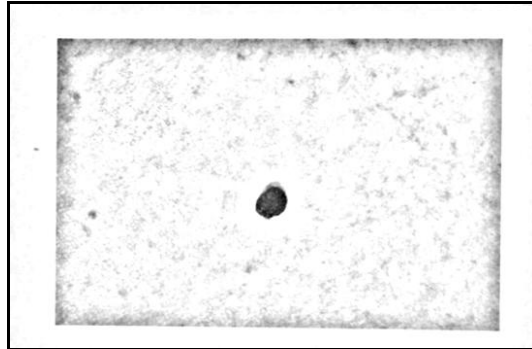
(d)

(e)

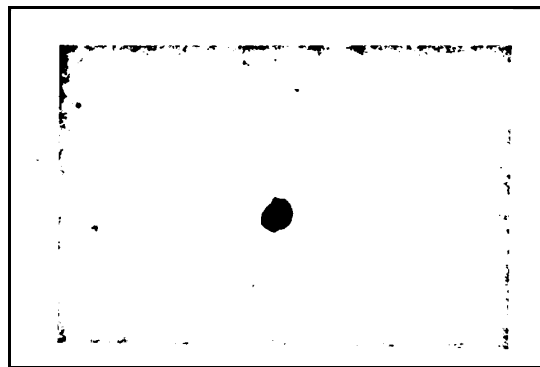
Figure 6.16: (c) Photocopy Filter, (d) Threshold,
(e) Threshold over Original Image

6.2.7. Image 15: Homomorphically Filtered Image#2

- **Photocopy:** Detail: 24 - Darkness: 5
- **Threshold:** Level: 165



(a) Photocopy-Detail: 24 - Darkness: 5



(b) Threshold: 165

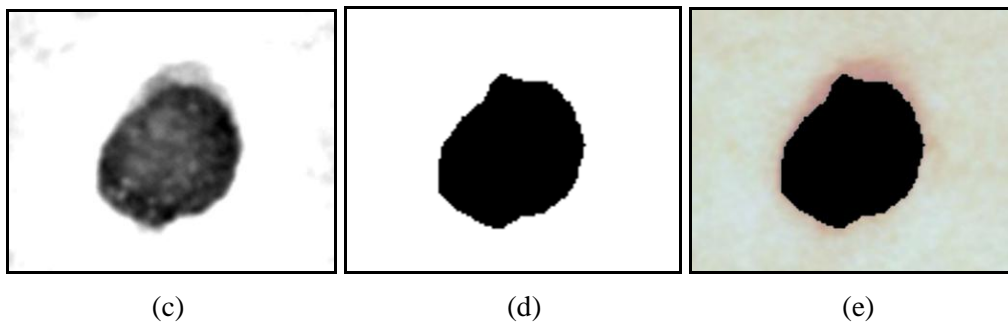
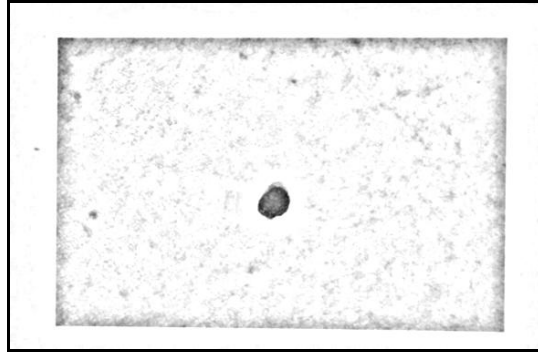


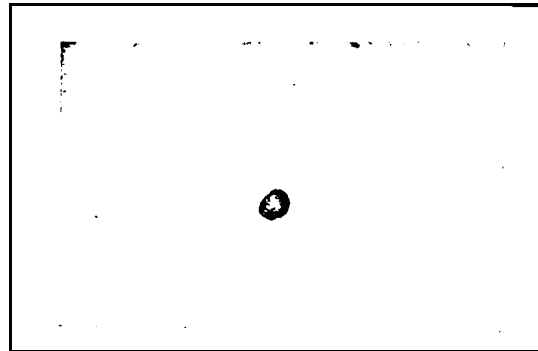
Figure 6.17: (c) Photocopy Filter, (d) Threshold, (e) Threshold over Original Image

6.2.8. Image 16: Homomorphically Filtered Image#2

- **Photocopy:** Detail: 20 - Darkness: 5
- **Threshold:** Level: 128



(a) Photocopy-Detail: 20 - Darkness: 5



(b) Threshold: 128



(c)

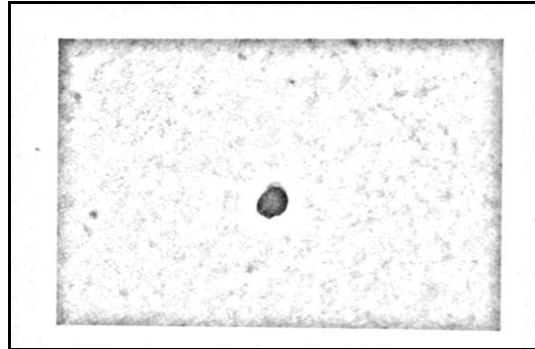
(d)

(e)

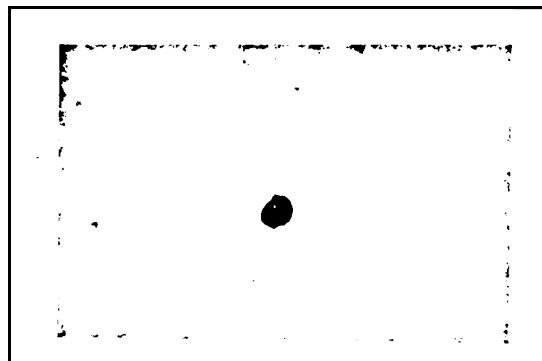
Figure 6.18: (c) Photocopy Filter, (d) Threshold, (e) Threshold over Original Image

6.2.9. Image 17: Homomorphically Filtered Image#2

- **Photocopy:** Detail: 20 - Darkness: 5
- **Threshold:** Level: 165



(a) Photocopy-Detail: 20 - Darkness: 5



(b) Threshold: 165

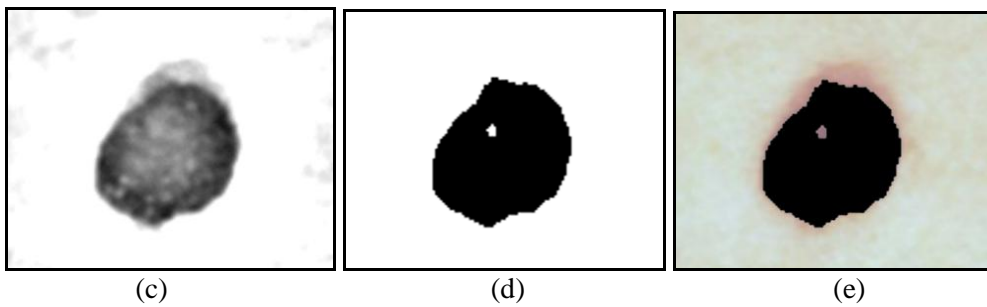


Figure 6.19: (c) Photocopy Filter, (d) Threshold, (e) Threshold over Original Image

6.3. Gray Scale - Stamp Filter

Stamp filter that lies under “sketch” section of filters in the Photoshop menu gives the best result on grayscale images (Adobe Photoshop Help Center). For this reason, images first need to be converted into grayscale images, after that by changing the two conditions that are light/dark balance and smoothness in the stamp filter, images can be modified in order to reach the intended result.

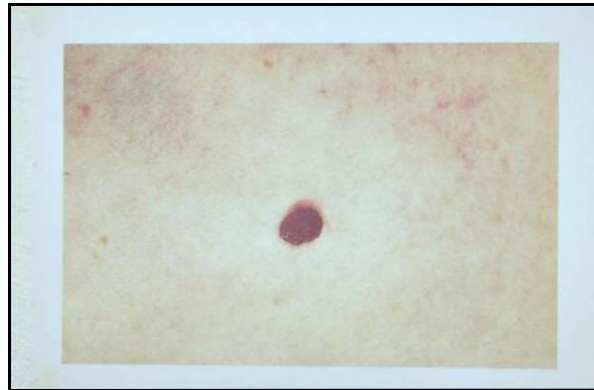
- **Light/Dark Balance:** It determines the strength of the filter that shows the anomalies on skin.

- **Smoothness:** it indicates the detail included from original image into resultant image. As the smoothness value rise up, details disappear.

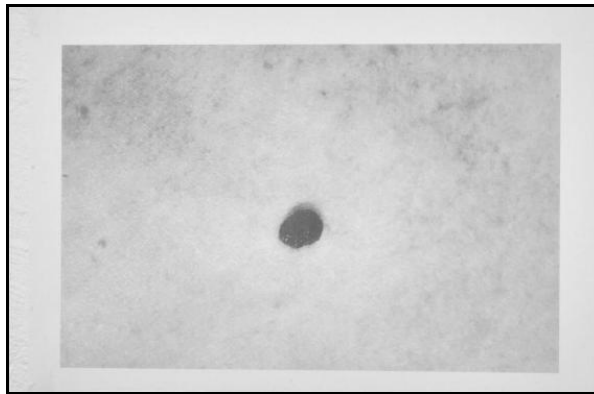
Some results can be seen in below.

6.3.1. Image 18: Homomorphically Filtered Test Image#1

- **Stamp Filter:** Balance: 25 - Smoothness: 1

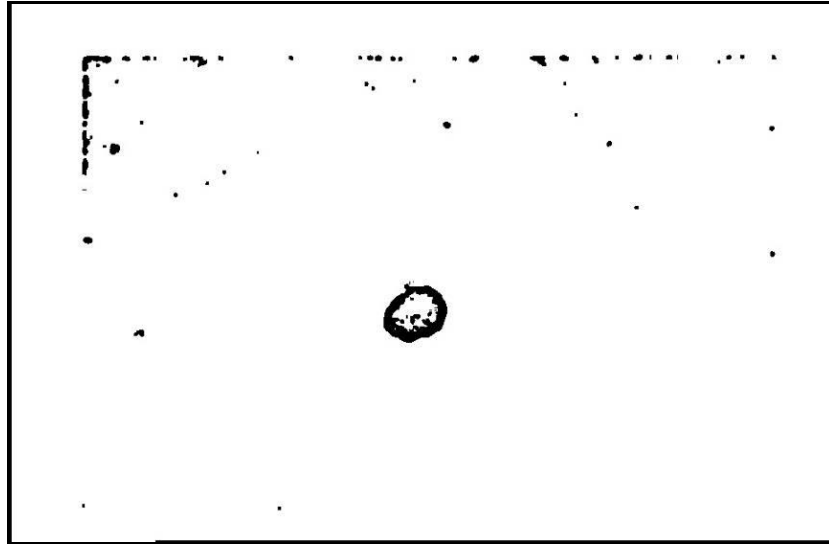


(a) Original Image

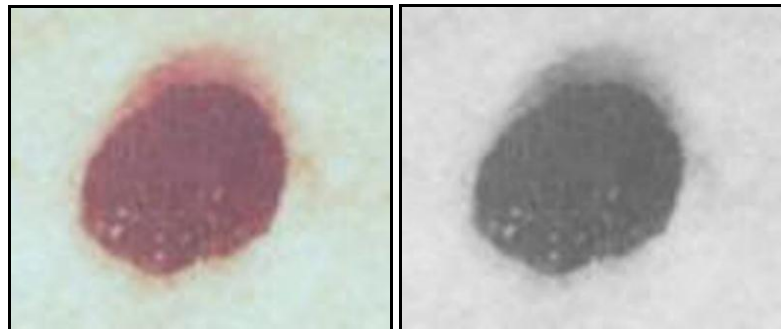


(b) Grayscale Image

Figure 6.20: Gray Scale - Stamp Filter of Homomorphically Filtered Test Image#2

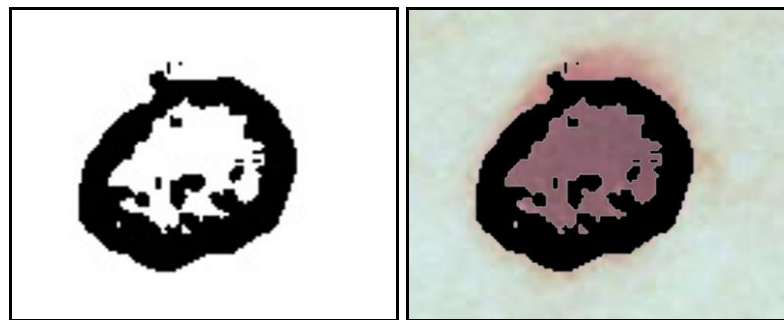


(c) Stamp Filter - Balance: 25 - Smoothness: 1



(d)

(e)



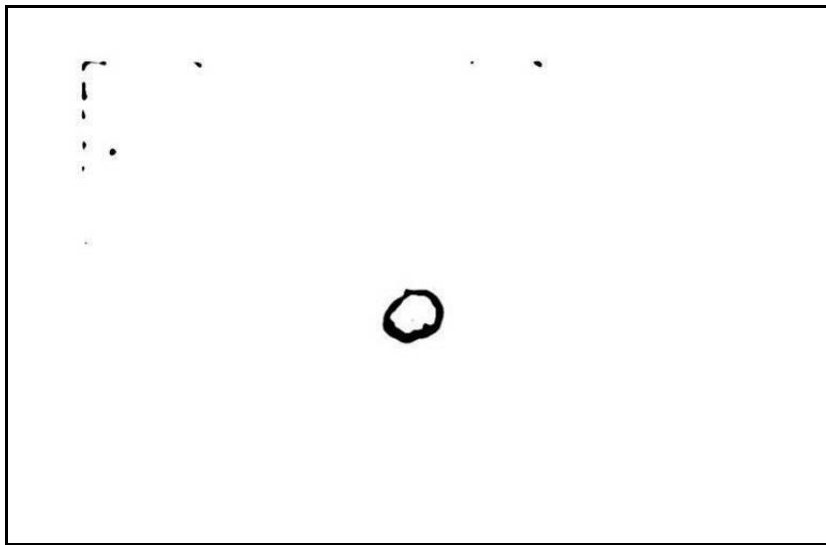
(f)

(g)

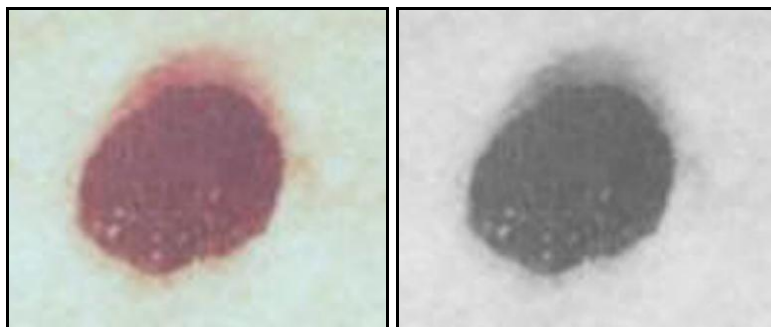
Figure 6.20 (contd.): (d) Magnification of original image, (e) Magnification of Gray Scale, (f) Magnification of Stamp Filter, (g) Magnification of Stamp Filter over Original Image

6.3.2. Image 19: Homomorphically Filtered Test Image#1

- **Stamp Filter:** Balance: 30 - Smoothness: 7

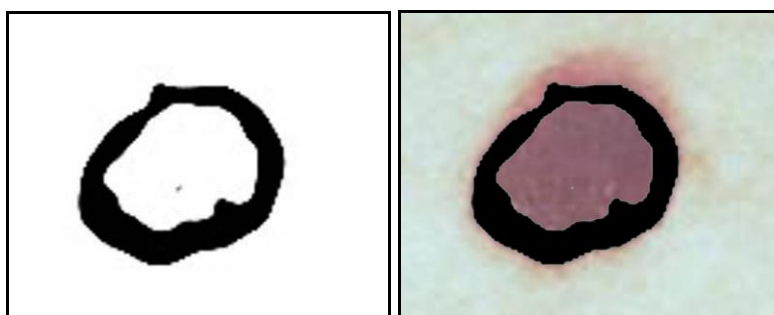


(a) Stamp Filter - Balance: 30 - Smoothness: 7



(b)

(c)



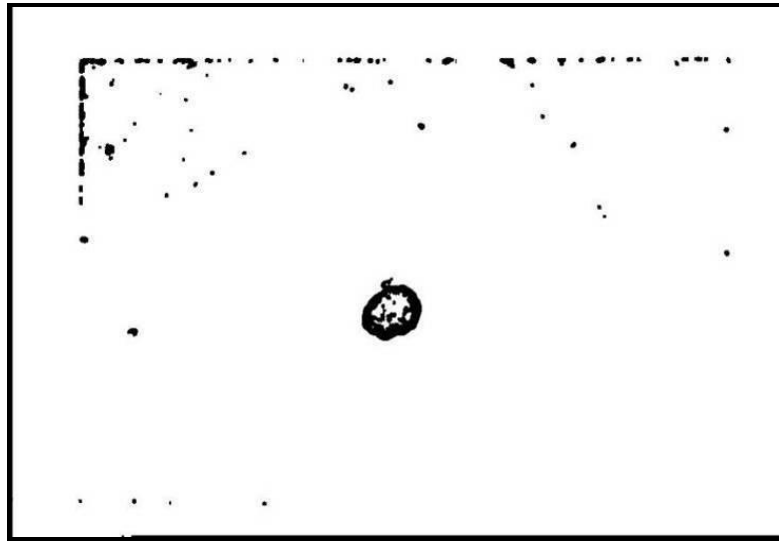
(d)

(e)

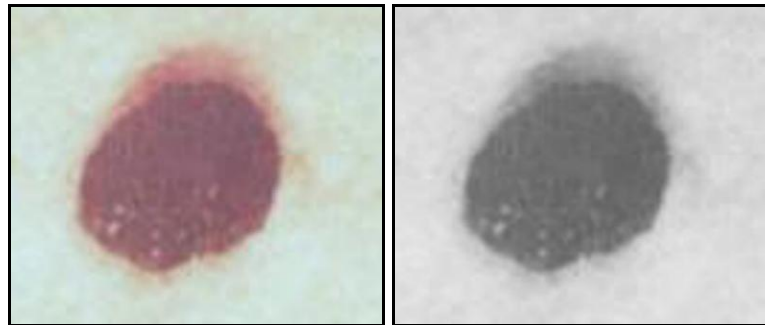
Figure 6.21: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.3.3. Image 20: Homomorphically Filtered Test Image#1

- **Stamp Filter:** Balance: 30 - Smoothness: 1

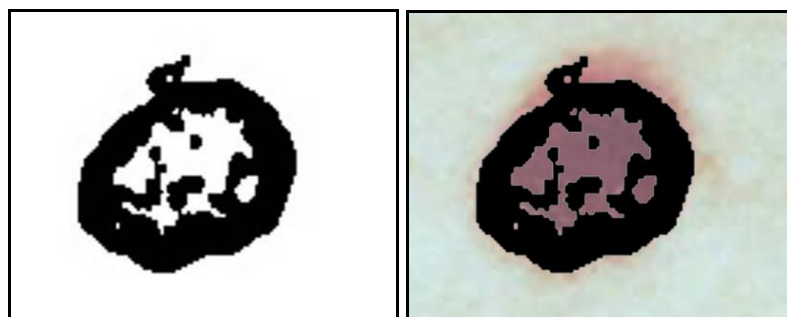


(a) Stamp Balance: 30 - Smoothness: 1



(b)

(c)



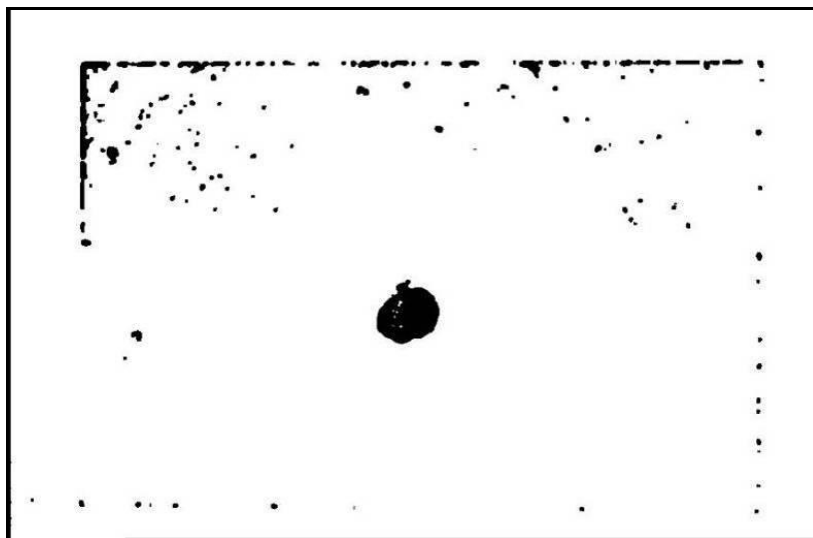
(c)

(d)

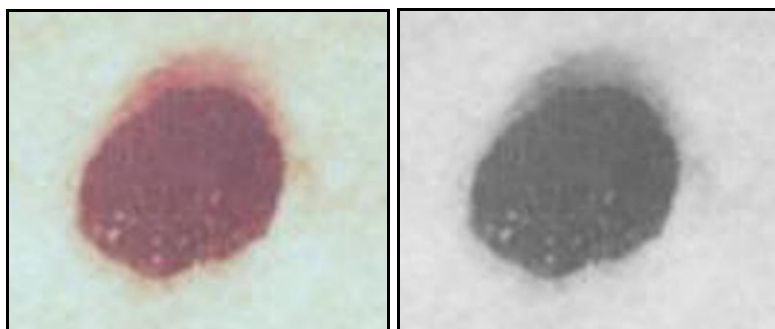
Figure 6.22: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.3.4. Image 21: Homomorphically Filtered Test Image#1

- **Stamp Filter:** Balance: 41 - Smoothness: 1

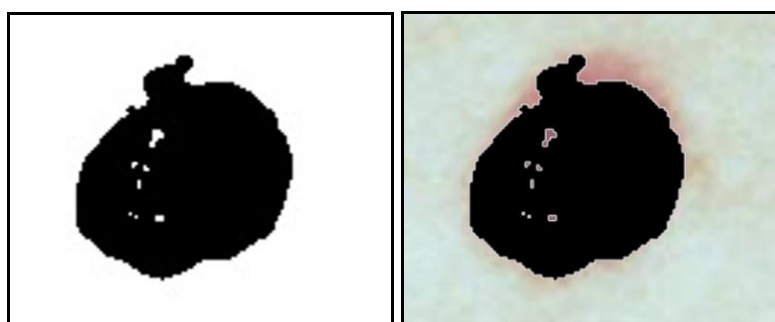


(a)Stamp Filter - Balance: 41 - Smoothness: 1



(b)

(c)



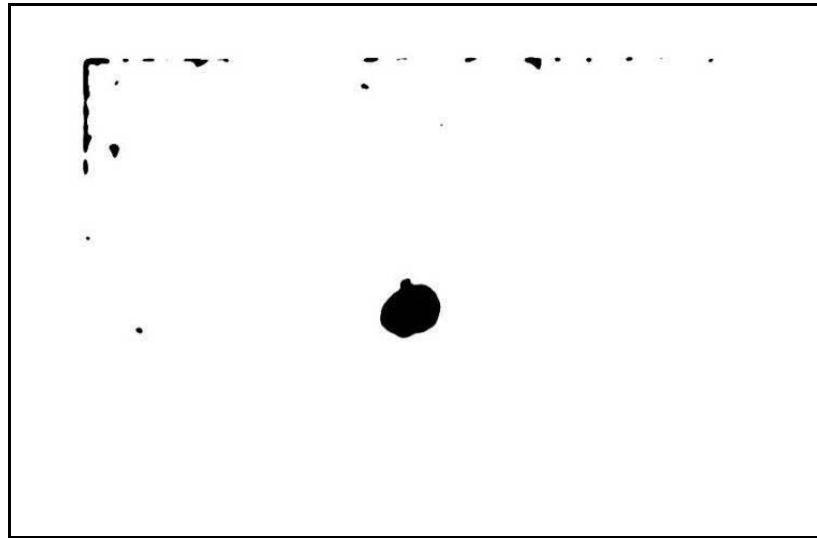
(d)

(e)

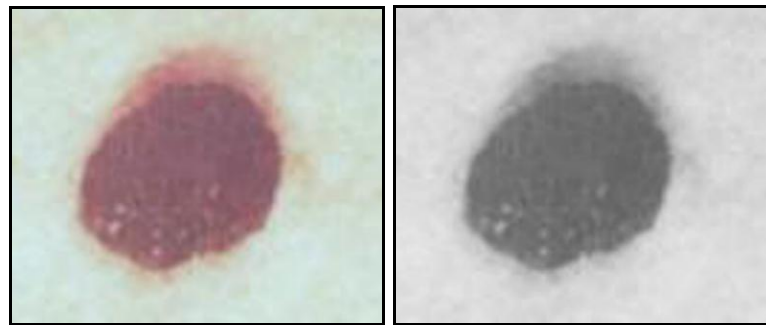
Figure 6.23: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.3.5. Image 22: Homomorphically Filtered Test Image#1

- **Stamp Balance:** 41 - Smoothness: 7

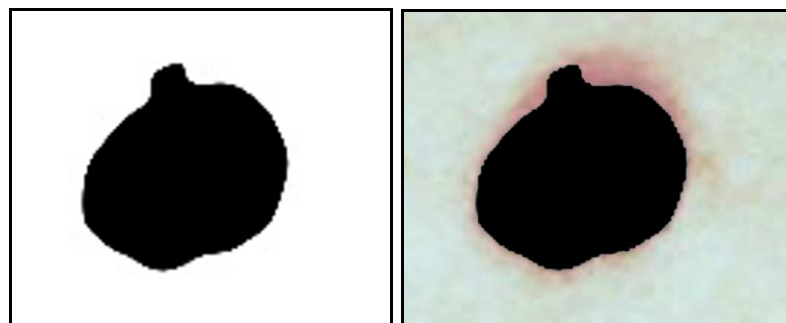


(a)Stamp Filter - Balance: 41 - Smoothness: 7



(b)

(c)



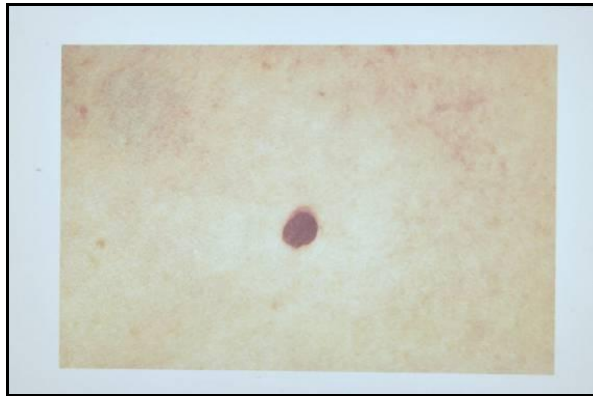
(d)

(e)

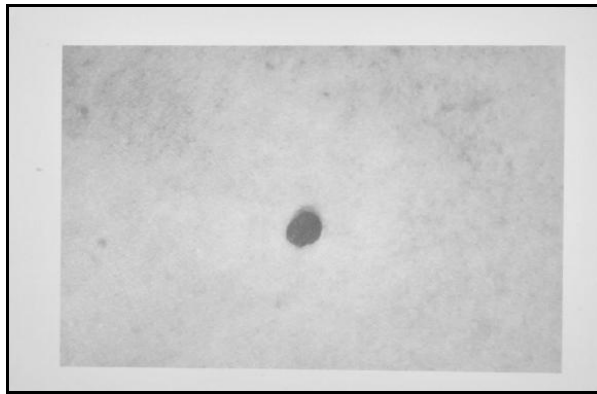
Figure 6.24: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.3.6. Image 23: Homomorphically Filtered Test Image#2

- **Stamp Filter:** Balance: 25 - Smoothness: 1

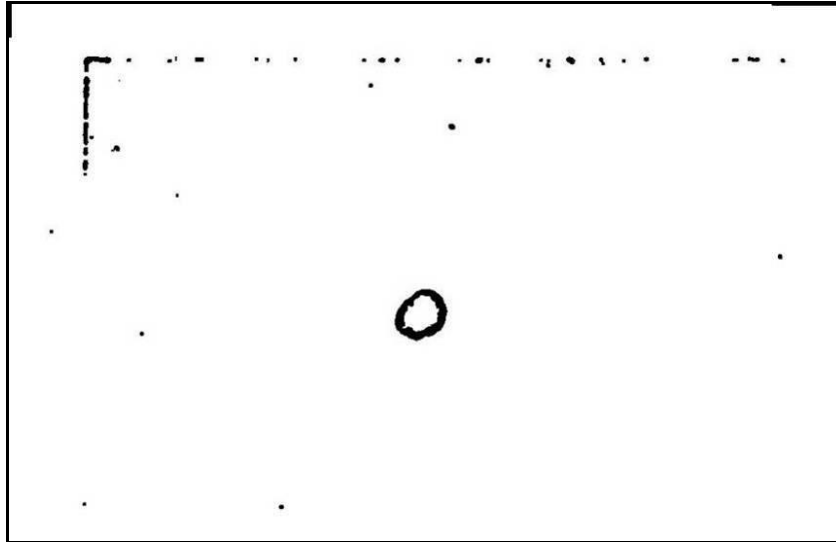


(a) Original Image



(b) Gray Scale Image

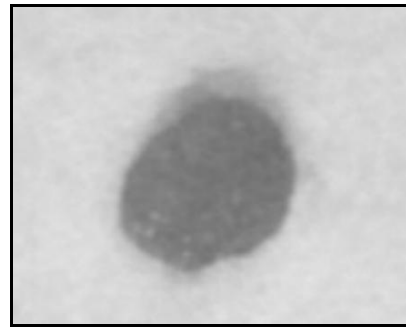
Figure 6.25: Gray Scale - Stamp Filter of Homomorphically Filtered Test Image#2



(c) Stamp Filter - Balance: 25 - Smoothness: 1



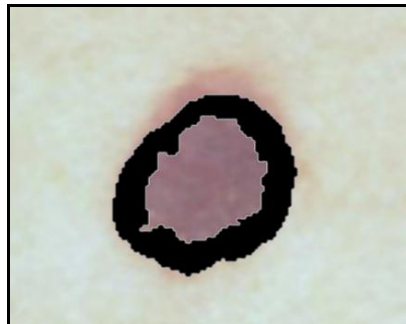
(d)



(e)



(f)

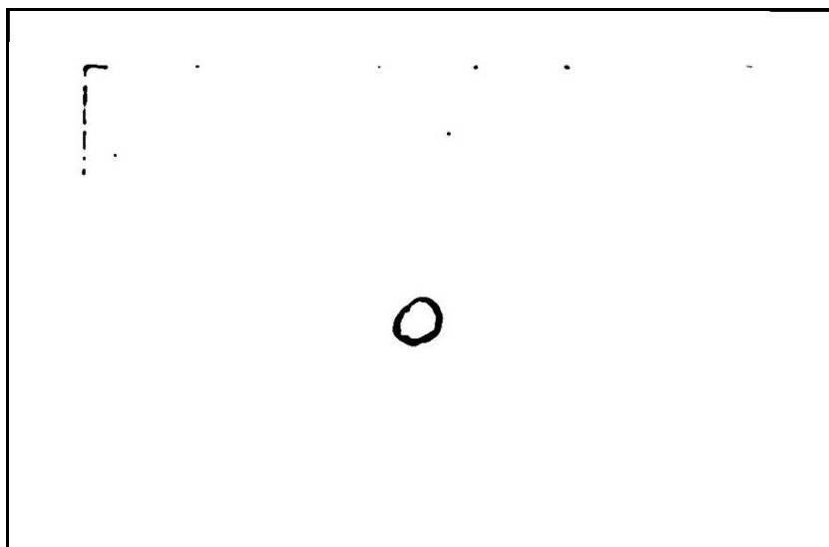


(g)

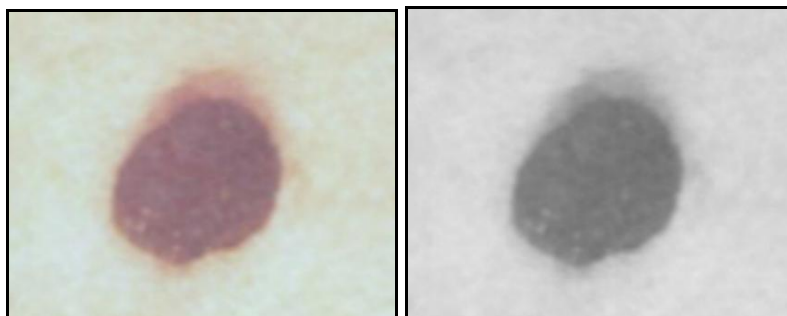
Figure 6.25 (contd.): (d) Original Image, (e) Gray Scale Image, (f) Stamp Filter, (g) Stamp Filter over Original Image

6.3.7. Image 24: Homomorphically Filtered Test Image#2

- **Stamp Filter:** Balance: 25 - Smoothness: 5

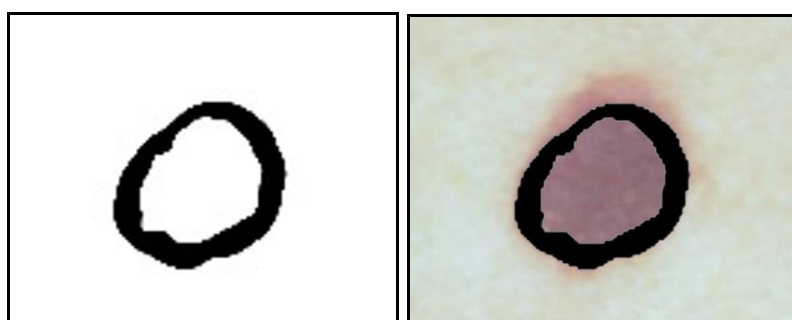


(a) Stamp Filter - Balance: 25 - Smoothness: 5



(b)

(c)



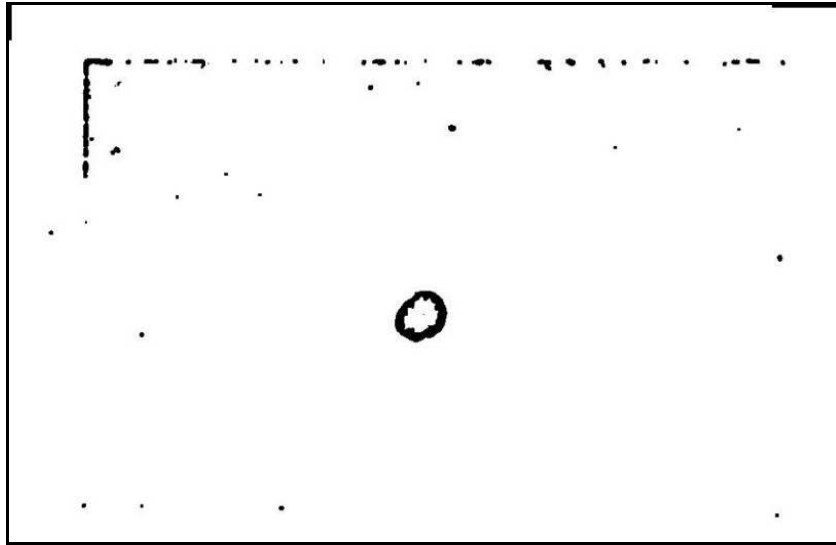
(d)

(e)

Figure 6.26: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.3.8. Image 25: Homomorphically Filtered Test Image#2

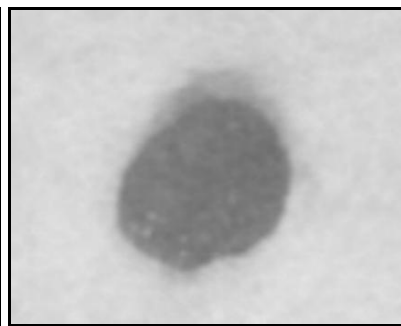
- **Stamp Filter:** Balance: 30 - Smoothness: 1



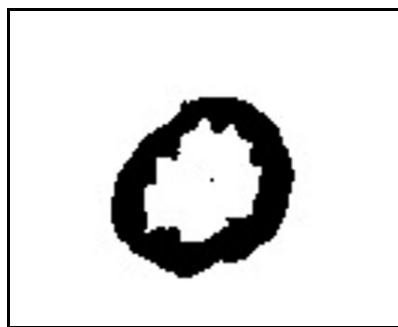
(a) Stamp Filter - Balance: 30 - Smoothness: 1



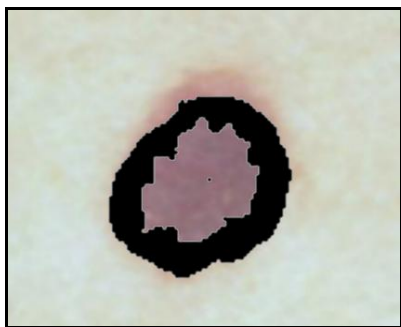
(b)



(c)



(d)

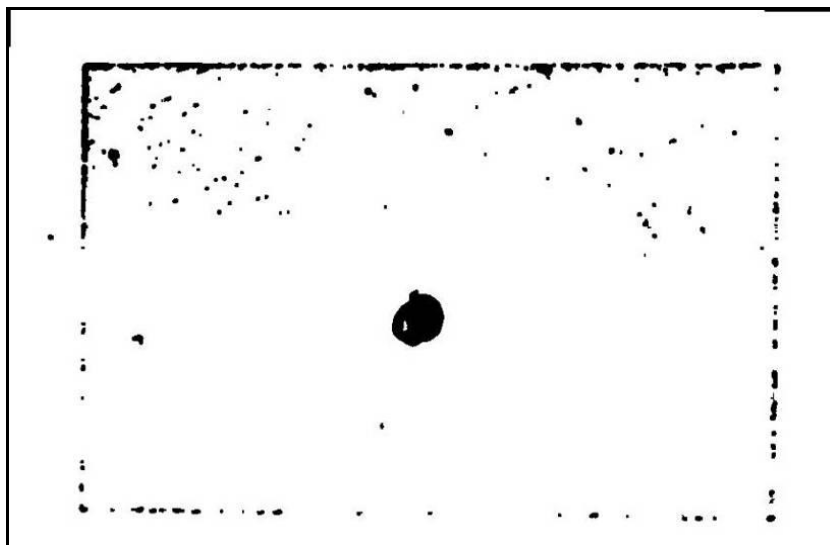


(e)

Figure 6.27: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.3.9. Image 26: Homomorphically Filtered Test Image#2

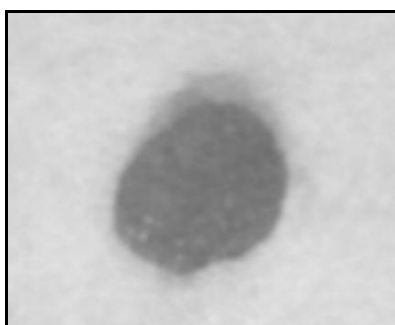
- **Stamp Filter:** Balance: 47 - Smoothness: 1



(a) Stamp Filter - Balance: 47 - Smoothness: 1



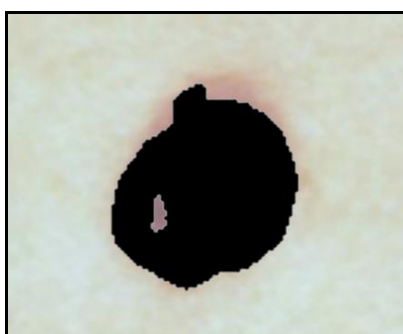
(b)



(c)



(d)

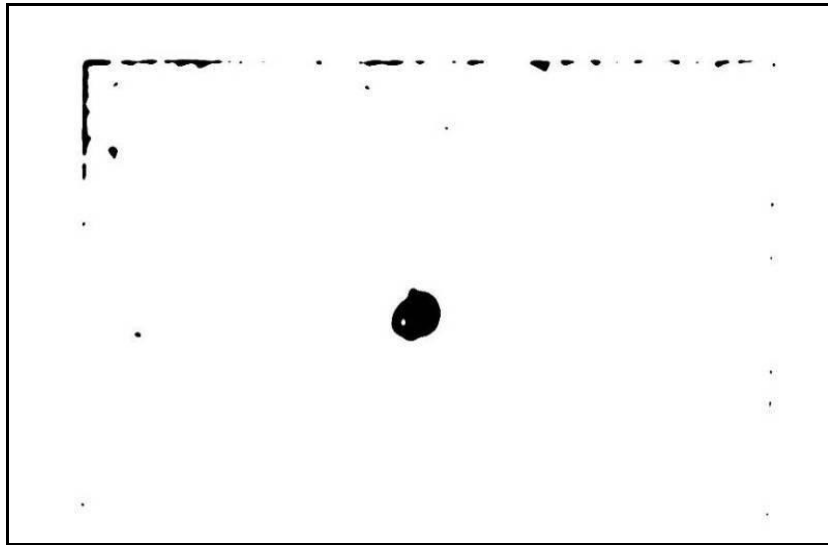


(e)

Figure 6.28: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.3.10. Image 27: Homomorphically Filtered Test Image#2

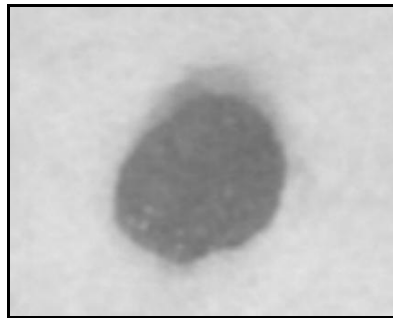
- **Stamp Filter:** Balance: 47 - Smoothness: 7



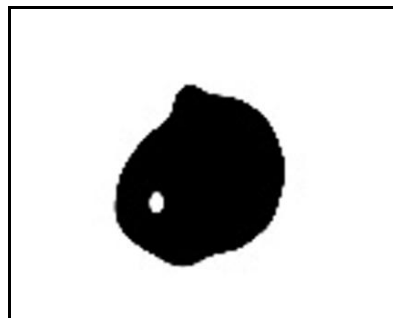
(a) Stamp Filter - Balance: 47 - Smoothness: 7



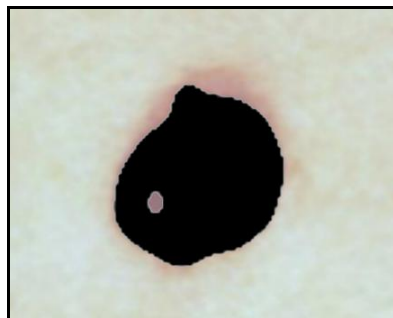
(b)



(c)



(d)



(e)

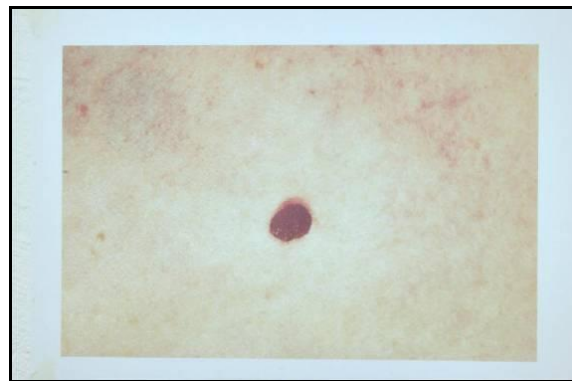
Figure 6.29: (b) Original Image, (c) Gray Scale Image, (d) Stamp Filter, (e) Stamp Filter over Original Image

6.4. Find Edges - Photocopy - Trace Contour

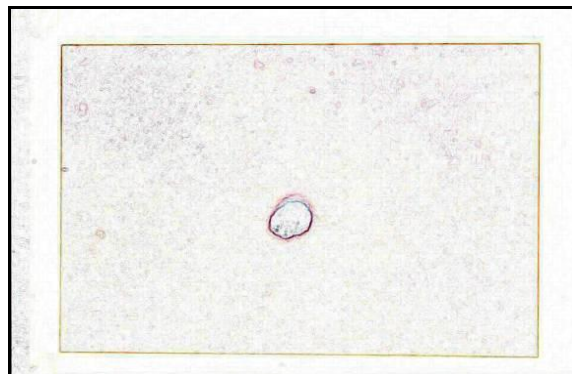
Find edges in “Styleize” section of filters in Photoshop menu highlights the areas with dramatic transitions and extracts the edges. It can be used for creating borders around an image area or around a specific pattern in an image.

6.4.1. Image 28: Homomorphically Filtered Test Image#1

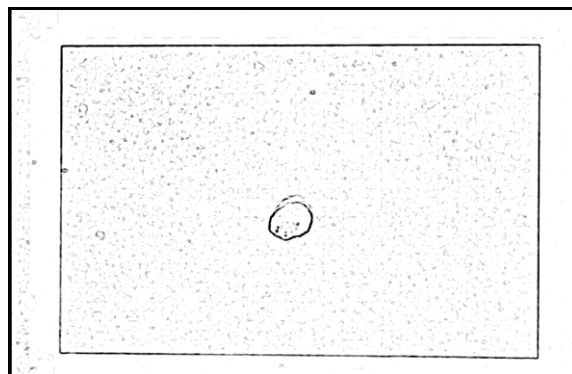
- **Photocopy:** Detail:5 - Darkness: 5
- **Trace Contour:** Level, Edge Lower: 128



(a) Original Image

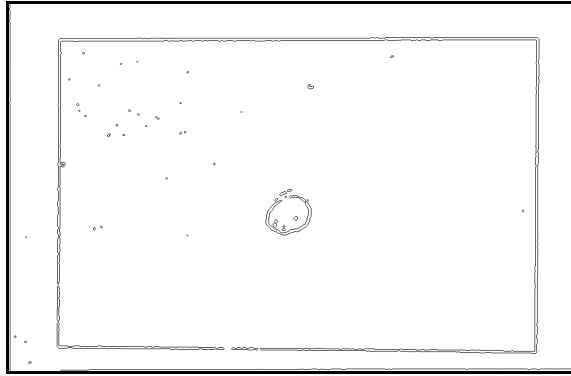


(b) Find Edges



(c) Photocopy - Detail: 5 - Darkness: 5

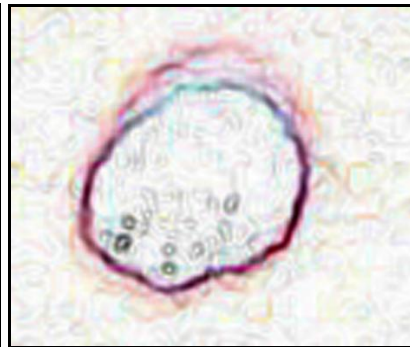
Figure 6.30: Find Edges - Photocopy - Trace Contour Filter



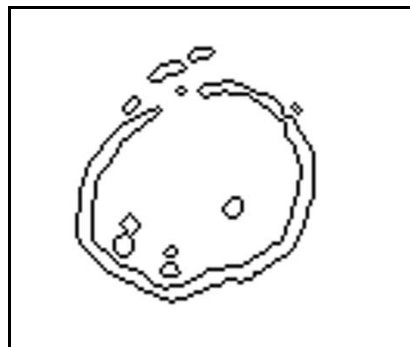
(d) Trace Contour - Edge Lower: 128



(e)



(f)



(g)

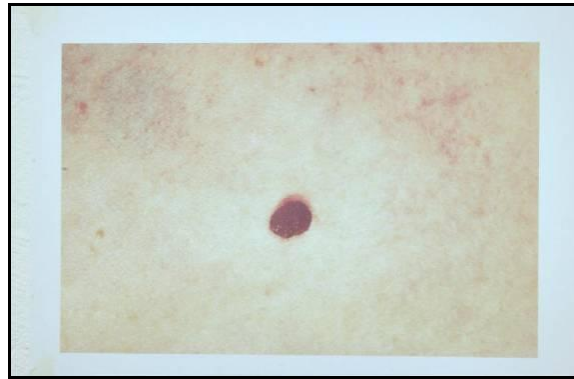


(h)

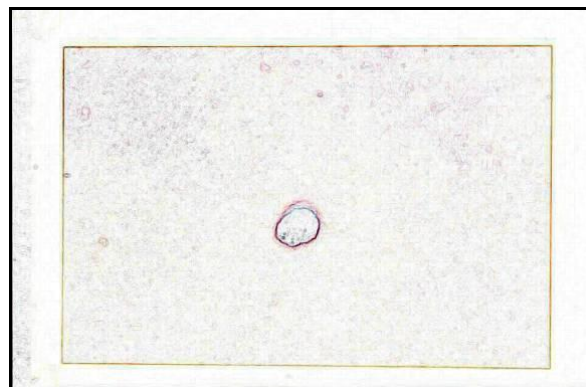
Figure 6.30(contd.): (e) Original Image, (f) Find Edges, (g) Trace Contour, (h) Trace Contour over Original Image

6.4.2. Image 29: Homomorphically Filtered Test Image#1

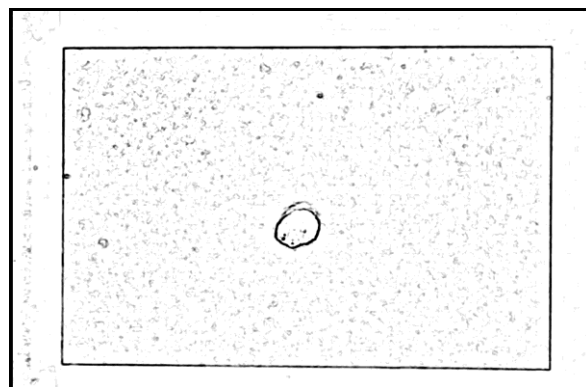
- **Photocopy:** Detail:10 - Darkness: 5
- **Trace Contour:** Level, Edge Lower: 140



(a) Original Image

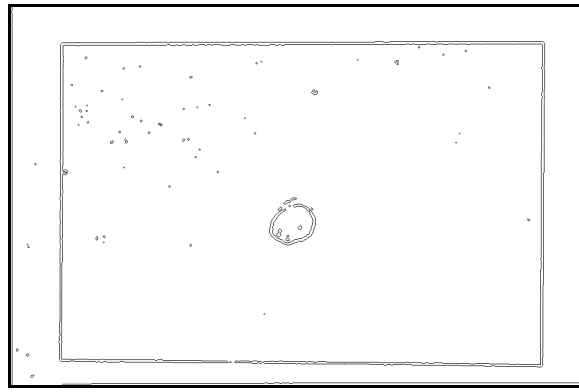


(b) Find Edges



(c) Photocopy Detail: 10 - Darkness: 5

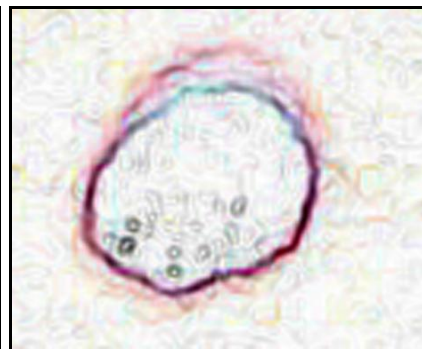
Figure 6.31: Find Edges - Photocopy - Trace Contour Filter



(d) Trace Contour - Edge Lower: 140



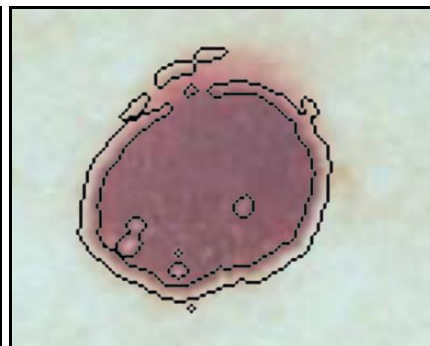
(e)



(f)



(g)

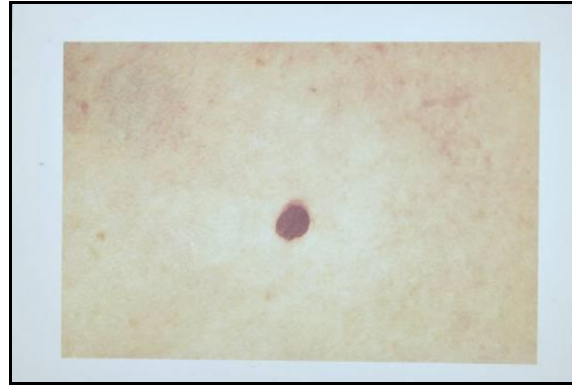


(h)

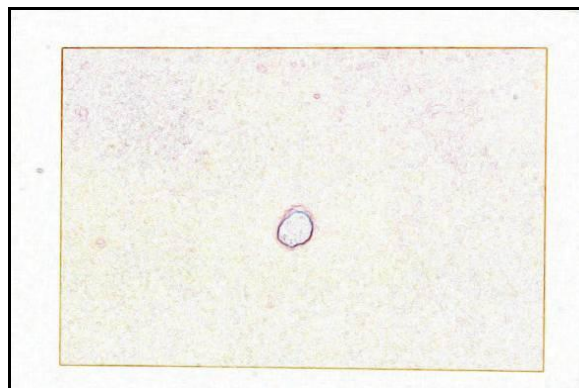
Figure 6.31(contd.): (e) Original Image, (f) Find Edges, (g) Trace Contour, (h) Trace Contour over Original Image

6.4.3. Image 30: Homomorphically Filtered Test Image#2

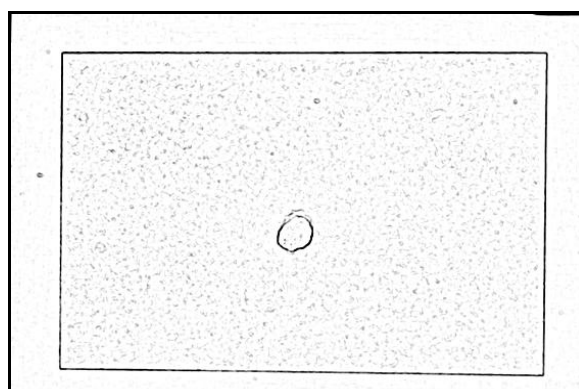
- **Photocopy:** Detail:5 - Darkness: 5
- **Trace Contour:** Level, Edge Lower: 128



(a) Original Image

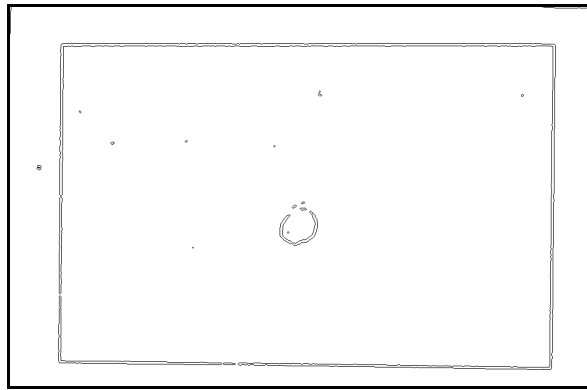


(b) Find Edges



(c) Photocopy Detail: 5 - Darkness: 5

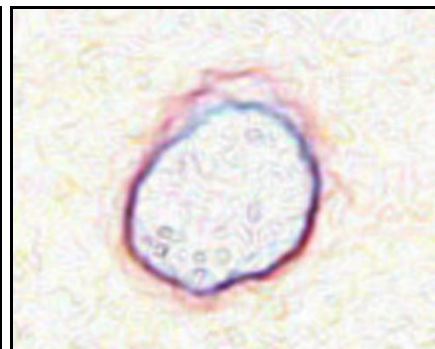
Figure 6.32: Find Edges - Photocopy - Trace Contour Filter



(d) Trace Contour - Edge Lower: 128



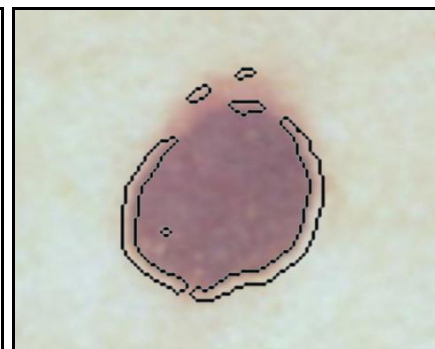
(e)



(f)



(g)

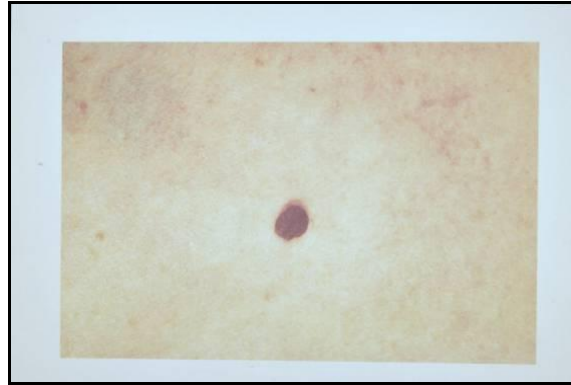


(h)

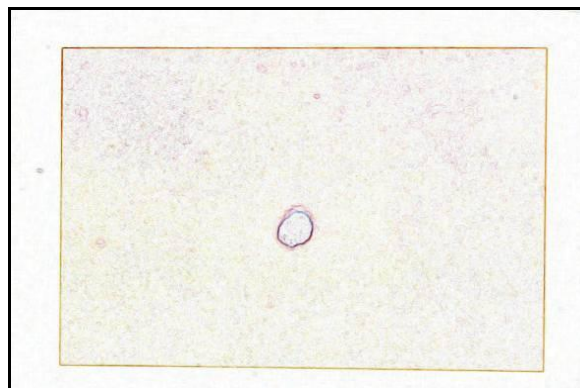
Figure 6.32(contd.): (e) Original Image, (f) Find Edges, (g) Trace Contour, (h) Trace Contour over Original Image

6.4.4. Image 31: Homomorphically Filtered Test Image#2

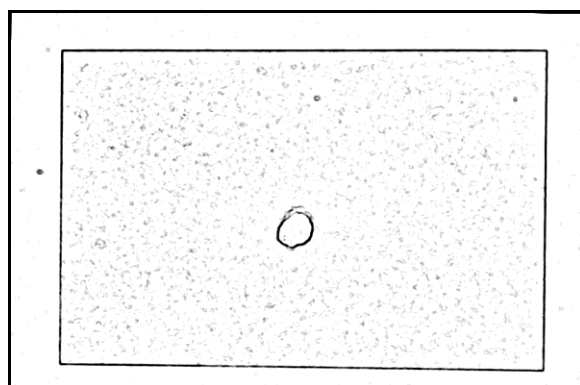
- **Photocopy:** Detail:10 - Darkness: 5
- **Trace Contour:** Level, Edge Lower: 140



(a) Original Image

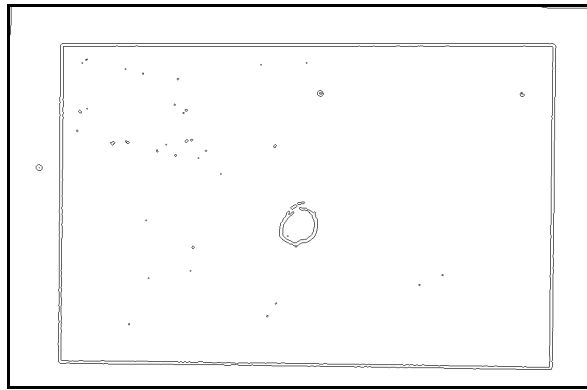


(b) Find Edges



(c) Photocopy Detail: 10 - Darkness: 5

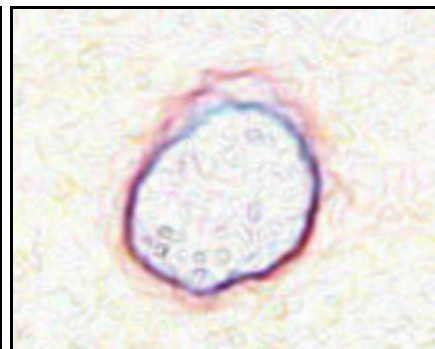
Figure 6.33: Find Edges - Photocopy - Trace Contour Filter



(d) Trace Contour - Edge Lower: 140



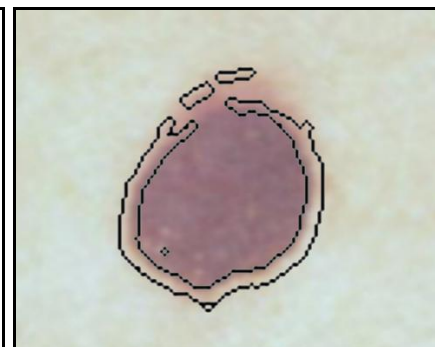
(e)



(f)



(g)



(h)

Figure 6.33(contd.): (e) Original Image, (f) Find Edges, (g) Trace Contour, (h) Trace Contour over Original Image

7. QUANTITATIVE ANALYSIS WITH PHOTOSHOP

Quantitative analysis on skin disorders is very important in order to see the evaluation of a disease. Analysis done by only visual observation by doctors is observer-dependent (Ramazani et al.) and moreover small changes might not be recognizable by human vision. Photoshop provides a user-friendly and amount effective tool to answer this purpose.

In this part of the thesis (as well as in the filter testing phase), Photoshop 7.0 was used to make quantitative analysis. Two images with different dimensions of the same scar on skin were analyzed. Because of the inability to access real patients, the tests were applied on printed images downloaded from the internet. It should be noted that, to make a final judgment about the validity of all Photoshop tools, more examinations must be done with the contribution of medical specialists and on real patient's skin diseases.

Quantitative analysis was performed using two different tools of Photoshop: “**Magic Wand**” and “**Magnetic Lasso**”. The Magnetic lasso tool requires more involvement of the operator than the Magic Wand tool. These tools determine the size of the scar in pixel dimensions that can be used for a reliable metric evaluation comparison. The mentioned methods were applied on the same scar images but with different characteristics (size). All image pairs were registered on each other and were converted to the same ground space in order to make the comparison feasible. This way it was possible to

- define some standards for this kind of temporal images' comparison and
- reveal the usefulness of the applied filters.

The Magic Wand tool specifies the adjacent area around a pixel which is selected by the operator. Two criteria, *tolerance value* and *contiguous* option, must also be determined.

- **Tolerance value** in pixels ranges between 0 and 255. This value must be selected low if it is preferable to select very similar pixels to the operator's

choice. Higher values widen the range of pixel differences between each other (Adobe Photoshop Help Center).

- **Contiguous** selection allows neighboring pixels to the operator's selection to be taken into consideration for the final selection of the area. Otherwise, only the similar pixels (within the given tolerance) will be taken into consideration

The Lasso tool lets the operator to draw borders freely while the magnetic lasso tool snaps the border to the edges of the defined areas in the image. Anti aliasing smoothes the edges and the feathering feature blurs the edges between the selection and its surrounding pixels. There are some extra options to determine the use of the magnetic lasso tool:

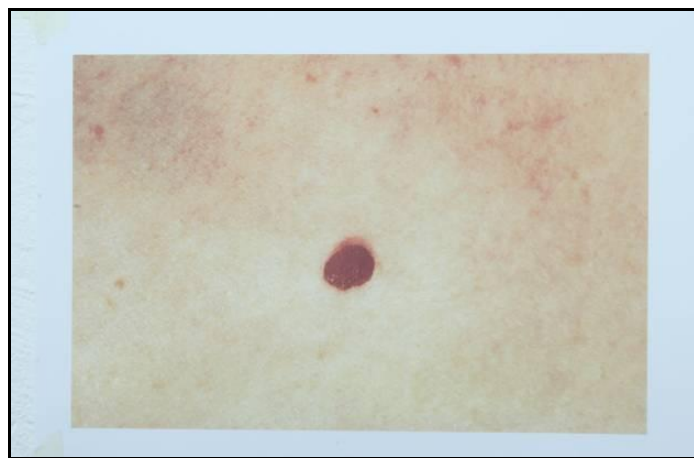
- **Width:** This value in pixels indicates the amount of the neighbor pixels which will be included into border.
- **Edge Contrast:** is the sensitivity to edges in image. Higher values detect only edges that differs highly contrast with its surroundings and lower value allows lower contrast selection.
- **Frequency:** specifies the rate between fastening points of lasso tool. Higher frequency means close-timbered selection will be done by software (Adobe Photoshop Help Center).

7.1. Original Images

Original image without any filter application was considered to determine the size of images and calculate the difference between them.

7.1.1. Magic Wand Tool

Tolerance was chosen as 30 and contiguous option was used during the application. The histogram under the image menu shows mean, median, standard deviation and pixel amount within the selection. In the Figure 7.1, an example of the procedure can be seen.

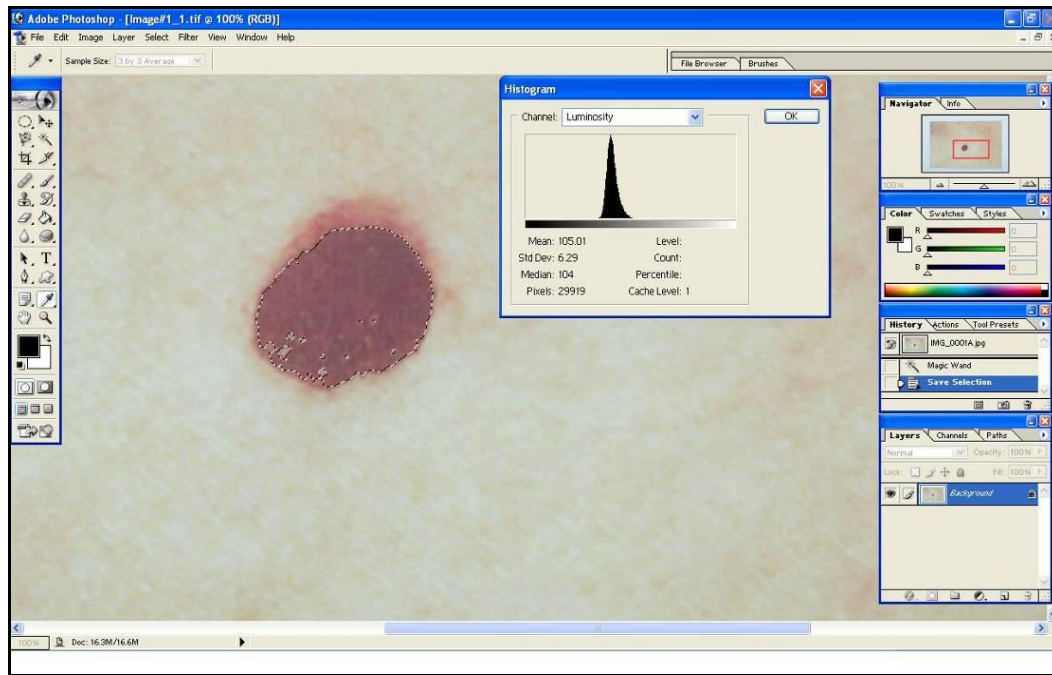


(a) Original image



(b) Magnification of original image

Figure 7.1: Magic Wand tool process on Photoshop 7.0



(c) Magic Wand tool selection on Photoshop 7.0

Figure 7.1(contd.): Magic Wand tool process on Photoshop 7.0

Every selection using the magic wand tool shows differences in amounts of four criteria mentioned above according to the selected pixel. Table 7.1 and 7.2 shows the 10 experiments applied separately on the original Test image#1 and Test Image#2 respectively.

Mean value represents the average intensity value within the selection, *median* indicates the middle value in the range, *standard deviation* is the variety amplitude in intensity values and *pixels included* shows the number of pixel within the border of selection.

Table 7.1: Magic Wand process on Test Image#1

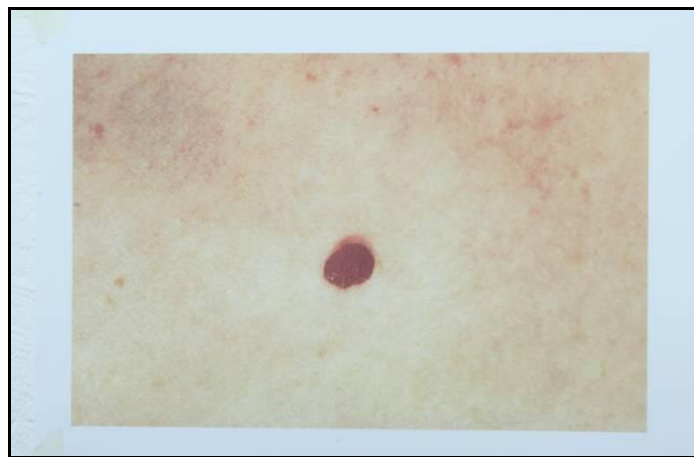
Number of trials	Mean	Median	Standard Deviation	Pixels included
1	105.00	104	6.29	29919
2	105.81	105	7.49	31089
3	105.19	104	6.51	30238
4	105.08	104	6.35	30068
5	105.88	105	7.50	31193
6	105.29	104	6.67	30368
7	104.87	104	6.11	29688
8	105.81	105	7.41	31110
9	105.62	104	7.15	30832
10	105.87	105	7.51	31176

Table 7.2: Magic Wand process on Test Image#2

Number of trials	Mean	Median	Standard Deviation	Pixels included
1	118.89	118	6.81	22848
2	119.08	118	7.08	23061
3	118.85	118	6.72	22827
4	118.19	118	5.86	22005
5	119.11	118	7.09	23098
6	118.59	118	6.37	22524
7	119.80	118	8.05	23794
8	118.77	118	6.62	22738
9	119.25	118	7.33	23219
10	119.91	119	8.33	23847

7.1.2. Magnetic Lasso Tool

While using Magnetic Lasso tool, anti-aliasing and feather choices were left to 0 because smoothness and blurriness is considered to cause lose of information and make the selection of edges harder. The selection width of 24 pixels (in diameter) was left unchanged as it was originally selected by the software; edge contrast was chosen to be 20% after some trial. This value can be chosen according to the color or contrast between the scar and normal skin and frequency 75 was considered enough to make a sufficient border. Figure 7.2 demonstrate the use of magnetic lasso tool in Photoshop 7.0.



(a) Original image

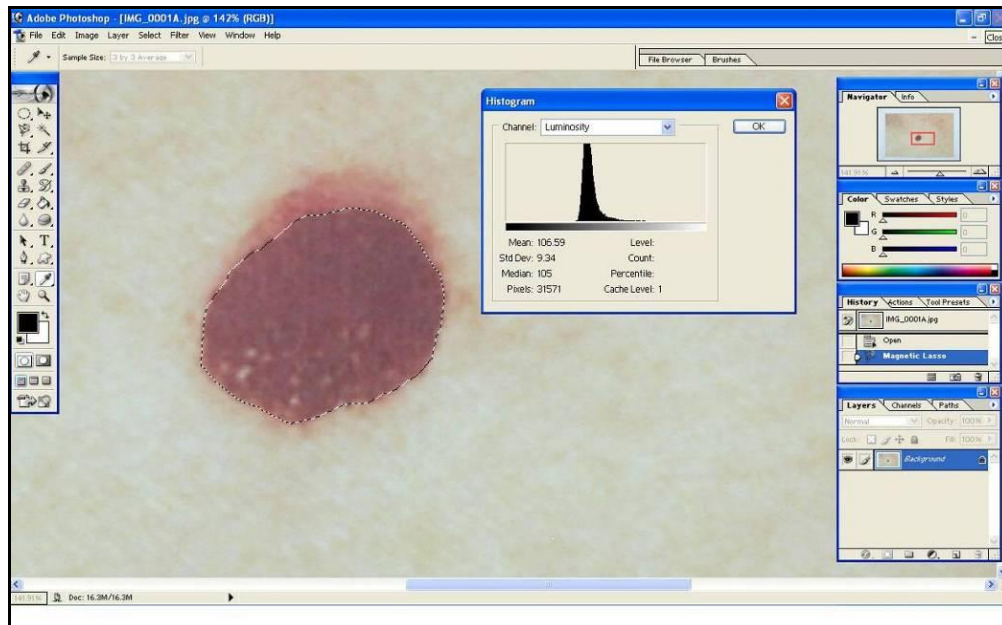


(b) Magnification of original image

Figure 7.2: Magnetic Lasso Tool by Photoshop 7.0



(c) Selection of border of scar by magnetic lasso tool.



(d) Magnetic Lasso tool and its histogram.

Figure 7.2(contd.): Magnetic Lasso Tool by Photoshop 7.0

Similar to the magic wand tool, magnetic lasso tests show four sets of selection results with its histogram. Because of that, ten different experiments were done by magnetic lasso also in order to make an optimization in between results. These results are displayed at the tables below for Test Image#1 and Test Image#2 respectively.

Table 7.3: Magnetic Lasso process on Test Image#1

Number of trials	Mean	Median	Standard Deviation	Pixels included
1	106.59	105	9.34	31571
2	106.56	105	9.31	31490
3	106.60	105	9.51	31500
4	106.66	105	9.45	31666
5	106.38	105	8.98	31310
6	106.44	105	9.11	31295
7	106.56	105	9.19	31585
8	106.56	105	9.22	31552
9	106.32	105	8.93	31204
10	106.49	105	9.06	31518

Table 7.4: Magnetic Lasso process on Test Image#2

Number of trials	Mean	Median	Standard Deviation	Pixels included
1	119.35	118	7.93	22984
2	119.00	118	7.38	22599
3	119.22	118	7.61	22947
4	119.42	118	7.98	23151
5	119.15	118	7.44	22.948
6	119.09	118	7.43	22807
7	119.18	118	7.51	22970
8	119.16	118	7.58	22840
9	119.31	118	7.69	23112
10	119.13	118	7.46	22851

7.2. Homomorphically Filtered Images

7.2.1. Magic Wand Tool

All area selection criteria were kept the same in the original images (tolerance is 30 and the contiguous pixels is enabled). Results after ten trials are displayed below (tables 7.5 and 7.6).

Table 7.5: Magic Wand process on Homomorphically Filtered Image#1

Number of trials	Mean	Median	Standard Deviation	Pixels included
1	116.43	114	9.37	3374
2	115.17	114	7.41	3226
3	114.84	114	6.93	3181
4	114.75	114	8.82	3167
5	114,86	114	6.94	3183
6	115.10	114	7.34	3213
7	114.75	114	6.82	3163
8	115.27	114	7.58	3238
9	114.46	114	7.41	3226
10	115.17	114	7.41	3226

Table 7.6: Magic Wand process on Homomorphicaly Filtered Image#2

Number of trials	Mean	Median	Standard Deviation	Pixels included
1	128.32	127	7.19	2401
2	128.64	127	7.67	2434
3	128.19	127	7.04	2385
4	128.32	127	7.19	2401
5	128.17	127	7.01	2383
6	129.01	127	8.22	2469
7	129.05	127	8.25	2473
8	128.83	127	7.94	2452
9	128.39	127	7.33	2407
10	128.15	127	7.34	2350

7.2.2. Magnetic Lasso Tool

Magnetic Lasso process was replied with homomorphically filtered test images and results are shown in the following tables, Table7.7 and Table 7.8

Table 7.7: Magnetic Lasso process on Homomorphicaly Filtered Image#1

Number of trials	Mean	Median	Standard Deviation	Pixels included
1	114.48	114	10.44	3336
2	114.76	114	9.04	3238
3	113.94	114	8.82	3262
4	114.54	114	9.49	3297
5	113.99	114	9.49	3297
6	114.16	114	8.87	3267
7	114.22	114	9.17	3261
8	114.65	114	10.42	3347
9	114.66	114	8.32	3217
10	114.04	114	8.32	3217

Table 7.8: Magnetic Lasso process on Homomorphically Filtered Image#2

Number of trials	Mean	Median	Standard Deviation	Pixels included
1	128.90	127	8.71	2422
2	128.67	127	8.34	2391
3	128.85	127	8.58	2418
4	128.90	127	8.86	2411
5	128.74	127	8.31	2412
6	128.51	127	8.13	2378
7	127.99	127	7.14	2332
8	128.17	127	7.41	2357
9	128.42	127	7.73	2380
10	128.94	127	8.80	2422

7.3. Results and Comparison between Original Images and Homomorphically Filtered Images

In order to reach a comparison result between two images that yields the evaluation of scars, the mean of ten trials of every experiment were calculated. These results are compared and displayed below. Table 7.9 shows the mean pixel values of the trials on Test Image#1 and Test Image#2.

Table 7.9: Average Pixels included of trials on Test Images

	Mean Pixels Included			
	Original Images		Homomorphically Filtered Images	
	Magic Wand	Magnetic Lasso	Magic Wand	Magnetic Lasso
Test Image#1	30568.1	31469.1	3219.7	3273.9
Test Image#2	22996.1	20628.4	2415.5	2392.3
Difference between Images	7572	10840.71	804.2	881.6

As seen from the results, it is not possible to make any comparison between original images and images after the homomorphic filter is applied, because the amount of the pixels in the original images, were reduced after its application. But in the case of the magic wand and the magnetic lasso tool the comparison can be achieved.

First of all, there is a significant difference in the amount of pixels selected when the two methods are used. During the application it was observed that the magic wand tool can exclude some pixels (from of manual operator's selection) depending on the tolerance value that is specified. This effect is shown in Figure 7.3. Red squares show the pixels which are not included in the selected area.

Another reason can be that, magnetic lasso is an operator depended tool. Operator selects the points and creates border manually from the beginning.

This enables the person to decide the extensity of the edging. In that way, the operator might select a wider border that he thinks it is part of the scar. On the other hand the magic wand tool is an automated tool that only results according to the digital numbers of the selected pixel.

Standard deviation rates are higher in magnetic lasso selection process at both the original and the filtered images. This can be the effect of exclusion of outlier pixels over scars by the magic wand tool. Also standard deviation represents the variation among the pixels in the selection area which reveals their difference in digital numbers. However, this does not mean that these pixels do not belong to the scar. Because of the type of the scar or because of some artificial effect some changes can be occurred in the mid area or anywhere inside the region as can be seen in Figure 7.3.

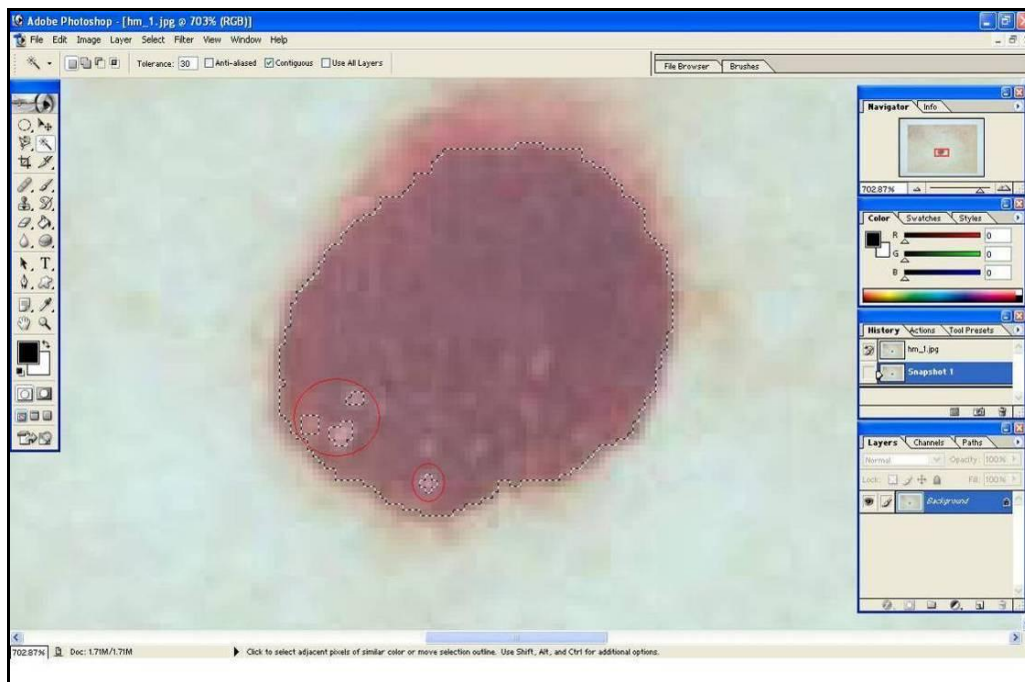


Figure 7.3: Pixels which are not included at result of Magic Wand tool process on homomorphically filtered Test

The validity of these selection processes must be examined with the help of medically trained professionals and in addition to this, inter- and intra-observer variability must be investigated. It will be within our future research interests to apply all the above mentioned techniques and algorithms in real dermatological examinations as soon as we get this opportunity.

7.4. Filtered Images

It is decided to apply Magic Wand tool as quantitative analysis to images which were modified with filters used above in order to see if it is possible to compare results derived from the comparison of the original images with the homomorphically filtered images. Filtered images were chosen according to their results which were considered most accurate or suitable to represent the whole scar on the skin by using overlay visualization of filtered and original images.

Because filtered images are only black and white images, magic wand tool is enough to calculate the amount of pixels and also it is enough to execute the tool once since there will be no change in the digital number of the pixel that is chosen by the operator inside the region of the scar. The total amounts of pixels of chosen filters are shown in the following table (Table 7.10).

Table 7.10: Magic Wand tool applied on filtered images

		Test Image#1	Test Image#2	Difference between Images
PHOTOCOPY - TRACE CONTOUR	Photocopy: Det:24 -Dark:5 Trace: Lower: 128		2409	
	Photocopy: Det:24 -Dark:5 Trace: Lower: 170	3500	2569	931
	Photocopy: Det:24 -Dark:10 Trace: Lower: 128	3637	2682	955
	Photocopy: Det:24 -Dark:10 Trace: Lower: 170	3783	2832	951
PHOTOCOPY - THRESHOLD	Photocopy: Det:24 -Dark:5 Thresh: Lower: 128		2409	
	Photocopy: Det:24 -Dark:5 Thresh: Lower: 165	3473	2547	926
	Photocopy: Det:20 -Dark:5 Thresh: Lower: 200	3537		
GRAY SCALE - STAMP FILTER	Balance: 41 (47 for #2) Smooth: 1	3767	2774	993
	Balance: 41 (47 for #2) Smooth: 7	3407	2457	950

7.5. Results and Comparison between Homomorphically Filtered Images and Enhanced Images

Since the filters for image enhancement were applied over homomorphic images results of magic wand tool on enhanced images are comparable only with homomorphically filtered images because of the amount of the pixel.

When the Test Image#1 and Test Image#2 are compared, it can be seen that total pixel amount difference calculated by magic wand tool is less on homomorphically filtered images than enhanced images (different filter applications). The numerical results can be seen Table 7.9 and Table 7.10. The reason of this difference is that, filters comprise some pixels from upper part which has lighter red color than main scar. But when the magic wand tool was used on non-enhanced images this part is not counted as adjacent pixels. The disparity can be seen in the Figure 7.4 below as an example.

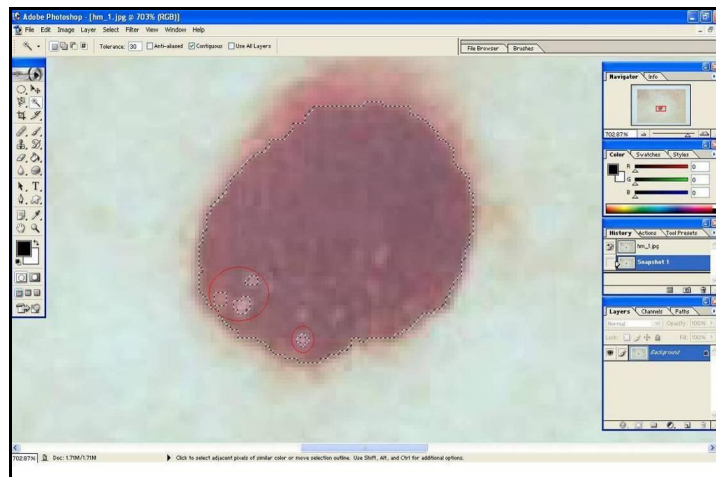
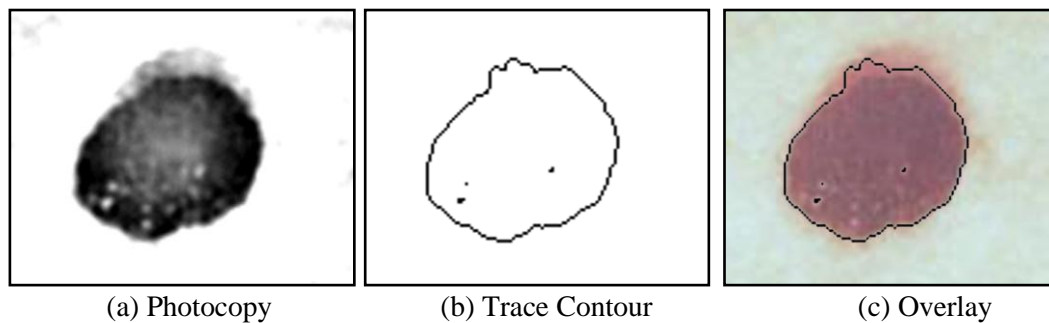


Figure 7.4: Photocopy: Detail: 24 - Darkness: 5, Trace Contour: Level, Edge Lower: 170 of “Test Image#1” and Magic Wand Tool application

8. CONCLUSIONS

As a conclusion, all the performed tests show that it is possible to use the filters mentioned above for the determination and monitoring of skin disorders. On the one hand they have achieved satisfactory results and on the other hand the software used (Photoshop) is user friendly and requires no special training or skills to use. The combination of the “Trace Contour - Photocopy” filters provides good results which are easy to interpret and provide some conclusions because they show not only the original image but also the border. On the contrary; “Find Edges-Photocopy-Trace Contour” filters don’t reveal exact boundaries. Parameters of filters are also another aspect which needs to be considered in further investigations concerning also the hurt area size on the image.

Quantitative analysis might constitute providence about the size of scar during the observation of the healing process but they must be evaluated very carefully.

Finally, in order to make any standard about this kind of study, different type of skin damages must also be investigated profoundly with in-depth information. Texture of the scar is another aspect, which should be taken into consideration in the stage of determination of the disorder. Besides the type of damage, colour is another important criteria that can provide auxiliary information. Especially with the usage of colour calibration method, some disorder type can be defined in charts and it disposes observer dependence in a considerable extend.

Photoshop is a really “cool” image processing tool and has been used for its big variety of tools (selection tools, filters etc) and its wide usage among people with different knowledge background on computers. All of the above mentioned algorithms and techniques should be developed and embedded in a dedicated software application in order to be used appropriately for the evaluation of skin damages. However, this is a kind of research that must be performed in different level and is far beyond the current work and thesis.

REFERENCES

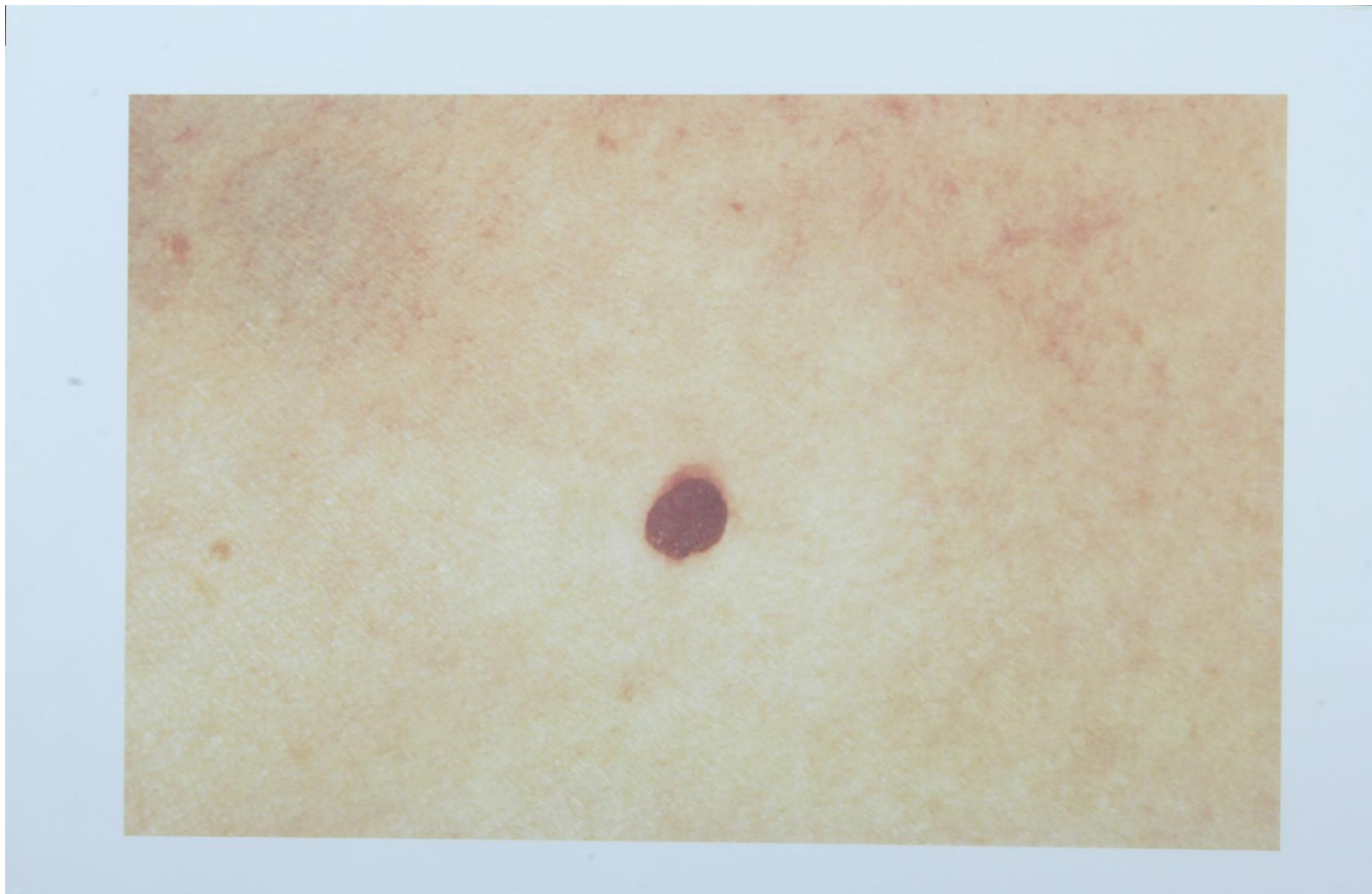
- Adelmann, H. G.**, 1998: Butterworth equations for homomorphic filtering of images. *Computers in Biology and Medicine* 28 (1998) 169±181.
- Al-Amri, S. S., Kalyankar, N. V., and Khamitkar, S. D.**, 2010: Linear and Non-Linear Contrast Enhancement Image, *International Journal of Computer Science and Information Security*, Vol. **10**, no.2, pp. 139-143
- Boersma, S.M., Van den Heuvel, F.A., Cohen, A.F., Scholtens, R. E. M.**, 2000: Photogrammetric Wound Measurement with a Three-Camera Vision System, *International Archives of Photogrammetry & Remote Sensing*, Vol. XXXIII Amsterdam, Netherlands.
- Box, G. E. P., and Jenkins, J. M.**, 1976: Time Series Analysis: Forecasting and Control. *Holden-Day, San Francisco, CA*.
- Lowe, D.**, 2005: Demo Software: SIFT Keypoint Detector, *The University of British Colombia*. Retrieved January 10, 2011 from: <http://www.cs.ubc.ca/~lowe/keypoints/>
- Matthys, D.**, 2001: Digital Image Processing, Retrieved January 1, 2011 from: <http://academic.mu.edu/phys/matthysd/web226/index.htm>
- Meng, Y., Tiddeman, B.**, n.d: 1981: Implementing the Scale Invariant Feature Transform(SIFT) Method, *University of St. Andrews, Department of Computer Science*, Retrieved December 28, 2011 from: http://www.cs.st-andrews.ac.uk/~yumeng/yumeng-SIFTreport-5.18_bpt.pdf
- Ramazani, A., Ahmadi, H., Azarmina, M.; Soheilien, M., Dehghan, M.H., Mohebbi, M.R.**, 2008: Agreement between clinical estimation and a new quantitative analysis by Photoshop software in fundus and angiographic image variables. *Springer Science+Business Media B.V. (2008)*
- Spartalis Yousif (Σπάρταλης Ιωσήφ)**, 2005: Digital Image Processing with Photogrammetric methods for medical purposes, *MSc Thesis*, Aristotle University of Thessaloniki, Thessaloniki, Greece.
- Wolf, P. R., Dewitt, B. A.**, 2000: Elements of Photogrammetry with Applications in GIS, 3rd Edition. pp. 431. *The McGraw-Hill Companies, Inc.*
- Url-1**< <http://usa.canon.com/content/rebelxti/EOS%20Digital%20Rebel%20XTi%20Spec.pdf> > accessed at 05.12.2010
- Url-2**< http://livedocs.adobe.com/en_US/Photoshop/10.0/ > accessed at 30.01.2011
- Url-3**< <http://www.asprs.org/> > accessed at 04.02.2011

APPENDICES

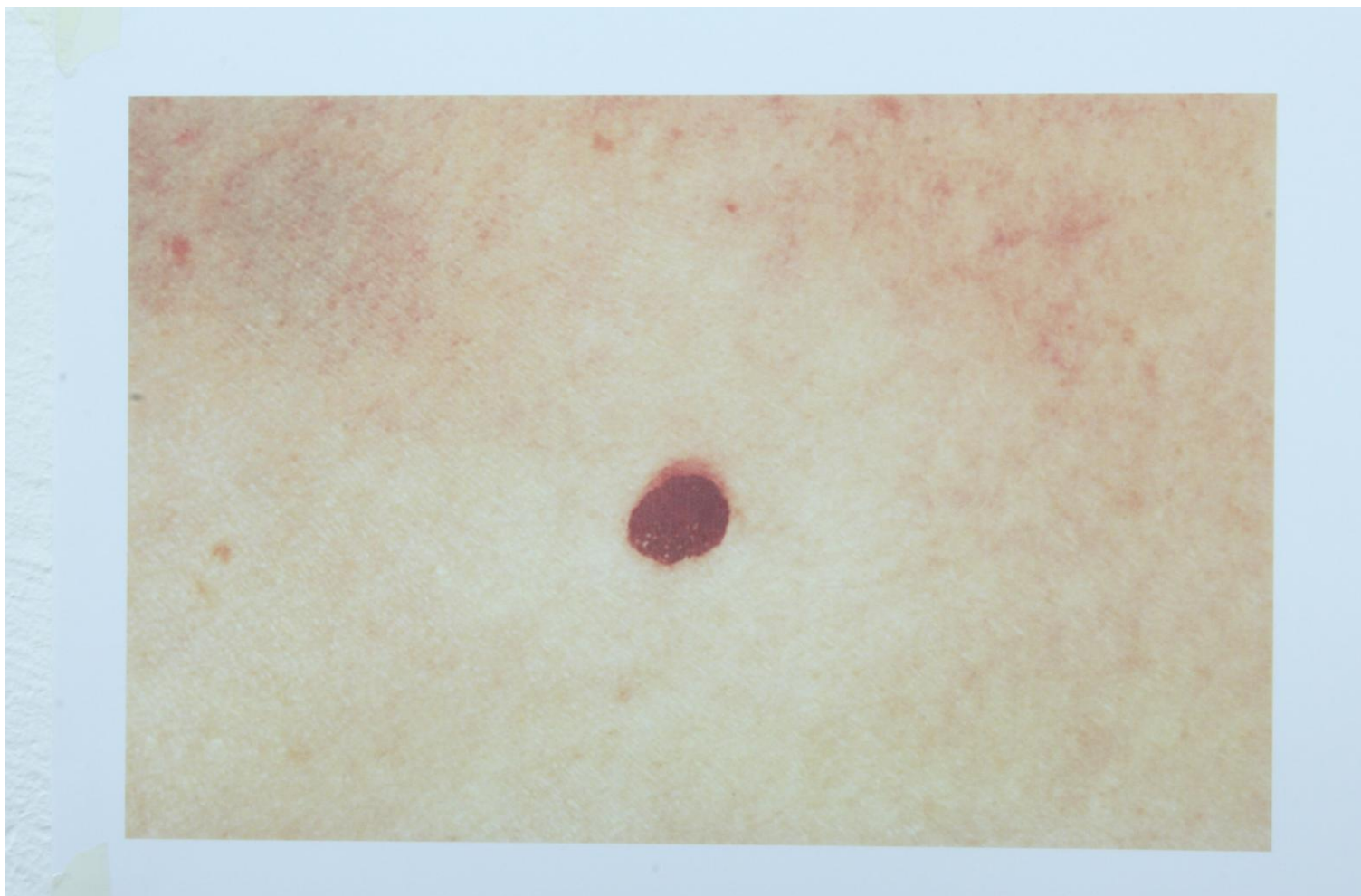
APPENDIX 1: Original Test Image#1

APPENDIX 2: Original Test Image#2

APPENDIX 1



APPENDIX 2



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