STUDYING THE EFFECT OF SOME IMAGE ENHANCEMENT FEATURES ON THE ACCURACY OF CLOSE RANGE PHOTOGRAMMETRIC MEASUREMENTS USING CAD ENVIRONMENT

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ABSTRACT

In computer graphics, the process of improving the quality of a digitally stored image by manipulating the image with software is called image enhancement. Advanced image enhancement software also supports many filters for altering images in various ways. We may be forced to apply one or more features of the image enhancement to the low quality photos to improve them for further phot ogrammetric use. This could be due to some of the unexpected photographic environment, which affect the images quality and needs something to be done to enhance the images for a better view. Applying such features may affect the accuracy in close range photogrammetric measurements. To find out the effect of these features in the close range photogrammetric measurements accuracy, a theoretical study on applying some of the image enhancement features were studied using CAD environment (3D Studio software), which can be used as an excellent tool for accuracy studies. Eight of Image enhancement feature were studied, re-size, sharpen, blur, midtone, contrast, highlight, shadow, and brightness. The original images were created using 3D studio MAX as a CAD environment, which enable us to get errorless image for a computer model as a test field. Three images were created (Left, centre, and right) for the test field. Each feature was studied by applying the feature on the original images with different percentages that makes total of 49 projects. Common photogrammetric software was used for the photogrammetric solution. The results was tabulated and statistically analysed to find out the effect of the image enhancement features on the accuracy. The study shows that ap plying some of the image enhancement features have effect on the measurements accuracy and some have no effect at all. This paper will show in details all steps and the results of the research.

1. INTRODUCTION

Digital close range photogrammetry is an important branch of the digital photogrammetry. It has a wide range of applications, which should be photographed from a near distance. The photographing in digital close range photogrammetry needs a highly care as the quality of the photos could be affected by several factors. One of the most important factors is the illumination, which could be natural or artificial. Any weak in this factor will lead to a weak photos quality, which will need to be enhanced through one or several image enhancement corrections. Applying such image enhancement features may affect the accuracy of the measurements.

Ebrahim M . and Farrag F. 2001 has proved that the CAD environment (3D Studio software) can be an excellent tool for accuracy studies. The CAD environment has a wide use in close range photogrammetry. Kraus K. 1997 mentioned, "A representation of the object surface based on edges and points is indeed possible and usable in CAD-system". There are a lot of researches that involved in using the CAD system in photogrammetry . As example, Coppola, F. et al 2000 has used both AutoCAD and 3D Studio as a CAD environment to display volumes as solids, rendering, and animation of the object. Also, Vogtle, Th. and Steinle, E. 2000 used CAD environment to visualise objects in 3D city models. In the worldwide webs we can find about 1330 site have mentioned the relation between the CAD and photogrammetry. In fact, the use of CAD system in photogrammetry is at end stages. In this paper, CAD system will be used at the beginning of the photogrammetric operation. In other word, it will be used as a photograph acquiring system.

Accuracy is an important element in the world of measurements, and it has been defined in several textbooks and articles. Accuracy is defined as the degree of conformity or closeness of a measurement to the true value. Accuracy includes not only the effects of random errors, but also any bias due to incorrect systematic errors. If there is no bias, the standard deviation can be used as a measure of accuracy (Mikhail E and Gracie G., 1981). Also, it is defined as the degree of conformity with a standard ("The Truth"). Accuracy can be evaluated by using one of the following two methods (Hottier, 1976):

- Check measurements
- The accuracy predictor.

In the first method, the photogrammetric results are compared with the results obtained from a more accurate measuring procedure. The accuracy predictor is a theoretical way to evaluate a system using its main parameters. If check points are available in the object space, the root-mean-square (RMS) error of photogrammetrically determined target point co-ordinates can be used as an accuracy measure (Fraser, 1990 and Hottier, 1976). Photogrammetry often estimates the accuracy of a method by controlled experiments, where the photogrammetrically determined co-ordinates are compared with so called given coordinates that have an accuracy that is considerably higher than that of the method to be checked (Ebrahim, 1992).

The procedures of evaluating accuracy in digital close range photogrammetry are common and well known. To evaluate the accuracy in digital close range photogrammetry we must have field measurements that can be compared with those measurements obtained from the photogrammetric application. The field measurements usually are accurate (up to a certain limit). This accuracy depends on the used instruments and on the mathematical models used to calculate the 2D or 3D co-ordinates. Brief definitions of the accuracy and how it can be achieved in the photogrammetric works have been mentioned by Ebrahim M. 2000. In general the accuracy can be obtained from the field measurements as follows:

- Choose a suitable test field to be used in the study (natural or artificial).
- Take some field measurements for the object to obtain the 2D or 3D co-ordinates for some chosen points (targets).
- Choose cameras configuration based on the factors that will be studied.
- Choose the suitable camera to be used.

- Take the photographs.
- Manage if the digital method or the traditional method will be used.
- M easure the photo co-ordinates of the targets.
- Calculate the object co-ordinates based on the photogrammetric solution.
- Compare the surveying co-ordinates with that obtained from the photogrammetric solution and make the required statistics.

With the great progress of the computer science, we have additional tools that enable us to make such studies easier and more efficient. CAD environment is a very suitable tool for such studies. Using such kind of software enable us to obtain an accurate 3D model without any field measurements. In this case, point's co-ordinates can be obtained directly from the model because we have the object with its accurate 3D dimension in the computer.

2. IMAGE EHANCEMENT

In computer graphics, the process of improving the quality of a digitally stored image by manipulating the image with software is called image enhancement. It is quite easy, for example, to make an image lighter or darker, or to increase or decrease contrast. Advanced image enhancement software also supports many filters for altering images in various ways. Programs specialized for image enhancement are sometimes called image editors. We may be forced to apply one or more features of the image enhancement to the low quality photos to improve them for further photogrammetric use. The applying of such features may affect the accuracy of the photogrammetric measurements. This study is trying to find out the effect of applying some of the image enhancement features on the digital close range photogrammetric accuracy. Eight features under different categories were applied. The features are re-sizing, sharpen, blur, tone balance (highlight – midtone – shadow), and Contrast/brightness.

2.1 Re-size

Change the horizontal and/or vertical size of an RGB or RGBa image using bicubic, bilinear or nearest neighbor interpolation. (Manifold system, 2004) When an image is resampled, an interpolation method is used to assign colour values to any new pixels it creates, based on the colour values of existing pixels in the image. The more sophisticated the method, the more quality and detail from the original image are preserved. (Photoshop , 2002) For Interpolation, one of the following options can be used:

- Nearest Neighbor (Jagged) for the fast but less precise method. This method is recommended for use with illustrations containing non-anti-aliased edges, to preserve hard edges and produce a smaller file. However, this method can result in jagged effects, which become apparent when distorting or scaling an image or performing multiple manipulations on a selection.
- (Photoshop) Bilinear for a medium-quality method.
- Bicubic (Smooth) for the slow but more precise method, resulting in the smoothest tonal gradations.

Bicubic interpolation method was used in this study.

2.2 Sharpen

The Sharpen filters focus blurry images by increasing the contrast of adjacent pixels. The Sharpen Edges filter sharpens only edges while preserving the overall smoothness of the image. Use this filter to sharpen edges without specifying an amount. For professional colourcorrection, use the Unsharp Mask filter to adjust the contrast of edge detail and produce a lighter and darker line on each side of the edge. This process will emphasize the edge and create the illusion of a sharper image. Unsharp Mas k was used through this study.

2.3. Blur

The blur filters soften a selection or an image, and are useful for retouching. They smooth transitions by averaging the pixels next to the hard edges of defined lines and shaded areas in an image.

2.4. Tone Balance

The Tone Balance is consists mainly of three different tone which are Shadow, Midtone, and Highlight. These tones can be changed by applying the same amount of the colour level for the three main colours (red – green – blue) with activating the wanted tone.

2.5. Contrast/Brightness

The Brightness/Contrast lets you make simple adjustments to the tonal range of an image. Unlike Curves and Levels, it makes the same adjustment to every pixel in the image. The Brightness/Contrast not work with individual channels and is not recommended for high-end output, because it can result in a loss of detail in the image.

3. SIMULATED ACCURACY STUDY

A simulation accuracy study was done in order to find out the effect of applying some of the image enhancement features in the digital close range photogrammetric accuracy. According to Ebrahim M. and Farrag F. 2001, CAD environment (3D Studio software) can be an excellent tool for accuracy studies. So, this study has used the CAD environment as an image-acquiring tool as it gives errorless images and errorless ground points coordinates.

3.1. 3D-Studio

In fact , 3D Studio software is designed to enable numerous creative professionals to work on specific aspects of the same project while easily combining discrete elements into complex shots, animations, or game levels. The software also boasts a redesigned renderer that retains the speed of its predecessor while delivering superior results and simplifying the process of creating stunningly realistic images, scenes, and special effects. Other key enhancements include nestable external references, application-wide scripting and macro recording, a customisable work environment, powerful organic modelling capabilities, and a host of other new features that accelerate the creation of digital content (3D Studio, 1996). 3D Studio uses also, a very useful feature for the photogrammetrist. This feature is the cameras. It uses two different types of cameras, free and target. The most used camera is the target type that enables us to position the camera in a certain position and direct it to a certain direction and a target. This enables us to fix the camera orientation elements.

3.2. The Idea of Using 3D Studio

3D Studio, as a CAD environment, enables us to create an

accurate 3D model. It is a very suitable environment to have a model that can be used as a test field for photogrammetric works. By creating a 3D model in this environment and have some photographs for this model from different points of view, we can use the photogrammetric techniques to obtain the 3D co-ordinates of this model. As mentioned before, 3D-Studio software has its great features that it offers the use of cameras, so we can use these cameras to obtain photographs of the model. The photogrammetric solution can be used to obtain the model co-ordinates. By comparing these co-ordinates with that of the original model, the accuracy of photogrammetric solution can be estimated.

3.3. 3D Studio Works

There are some works through 3D Studio software must be done to have the photographs that will be used in this study. These works are:

- • Create a test field model.
- • Define a camera.
- • Configure the cameras.
- • Render the scene each time using a camera position.

3.3.1. Creating the test field model: In 3D-Studio soft ware, a test field model has been created. The test field model consists of 40 posts with 20 x 0 mm cross section and with different heights vary from 0 to 20 cm. These posts have been fixed to a plan frame as zero datum. The posts arranged in horizontal rows and vertical bars with 20 cm distances centre line to centre line. To have a good photo contrast for marking the target points through the digital photogrammetric software, different materials for the posts and the frame have been assigned. Also, a target spotlight in the front of the test field has been used to illuminate the posts' top. Figure (1) shows the test field.

3.3.2. Define the camera: A camera through 3D Studio has been defined with 35 mm focal length, 36 X 24 mm format and 63-degree angle of convergent.
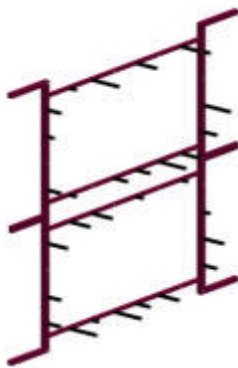

Figure 1. The Test Field

3.3.3. Camera configuration: Three cameras have been arranged in front of the object. The cameras' axes have been directed to the object centre. The camera configuration was set to achieve the best accuracy and to give a good intersection angles. Good intersection angles can be achieved by setting the B/H to 0.5 where B is the base distance between the two camera stations and H is the object distance (Ebrahim M., 1992). The obtained accuracy depends mainly on the intersection angles. It depends also on the number of used photos, which lead to a precise and reliable estimation of all camera parameters. As this study is focusing on the effect of applying some image enhancement feature in the accuracy and not on how much the

accuracy is, more concern about the intersection angles was taken into consideration more than the number of photos. Ebrahim M. and Farrag F., 2001 proved that a good camera configuration with less number of photos can lead to a better accuracy than bad camera configurations with large number of photos. The accuracy of stereometric model decreased by having convergent photographs; whereas others stated that the accuracy is increased (Abdel-Aziz , 1974). The convergent angle has no effect in the photogrammetric accuracy as it may increase or decrease depending on how the base distance between the cameras and the object distance values changes (Ebrahim M., 1992). So, the camera convergence angles are not considered, as it has no certain effect in the accuracy. The camera axis was pointed to the target centre. Figure (2) shows a plane diagram of the camera and the test field. Figure (3) shows the camera station in the 3D studio.
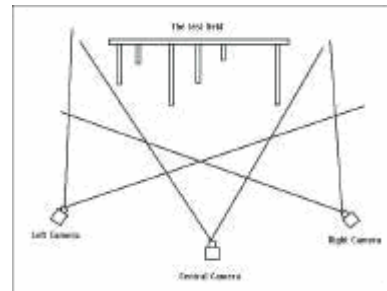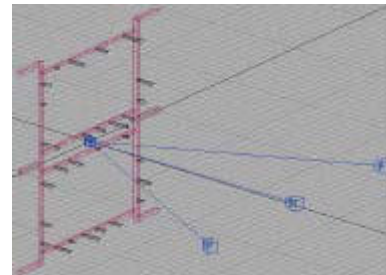

Figure 2. The Camera Configuration

Figure 3. 3D studio camera station positions

3.3.4. Rendering the scene: To have the photograph from each camera position, the view port must be assigned to view the appropriate camera scene. Then rendering the camera scene with fixing the rendering option to the desired resolution and saving under the desired file name.

3.4 Photogrammetric Solution

3.4.1 Used software: The core of any good photogrammetry package is a powerful bundle adjustment algorithm. A bundle adjustment is a complex algorithm that optimises all the data presented (camera information, user and system photo markings, etc) to indicate the best positions and angles of the camera at time of exposure, and the positions of the 3D data points (EOS Core Technology , 2003). The software used in this study was PhotoM odeler version Pro 3.0 from ESO system inc. (PhotoModeler, 2003). Nowadays, a new version of PhotoModeler is released (version 5) which offers automated camera calibration with sub-pixel measurements, which was not available at the time of study. Eos' Bundle Adjustment provides camera self-calibration and full error propagation. PhotoModeler does some camera selfcalibration, during its 3D processing, when there are sufficient marked points on the photographs. A less than ideal calibration will still produce

good models when the model has many points in it (over 50 3D points). With Self-Calibration PhotoModeler makes minor adjustments to the camera parameters on a perphotograph basis to account for changes in focal length, principal point and lens distortion as the camera lens is focused. PhotoModeler uses a standard lens distortion formulation with four parameters, which is a subsample of the parameter set introduced by (Brown, 1971). The following formulas describe how PhotoModeler applies the distortion corrections. The compensation for any point (x, y) of the image surface is given by (Wiggenhagen M., 2002):

$$x_c = x + r_x + p_x$$
$$y_c = y + r_y + p_y$$

Where x_c, y_c is the corrected image point, r_x is the x-component of the radial lens distortion correction, r_y is the y-component of the radial lens distortion correction, p_x is the x-component of the decentering lens distortion correction, and p_y is the y-component of the decentering lens distortion correction. The formula used by PhotoModeler for r (redial lens distortion) is given by:

$$r = K_1 * r^2 + K_2 * r^4$$

Where $r^2 = x^2 + y^2$

The formulas used by PhotoModeler for decentering lens distortion are:

$$p_x = P_1 * (r^2 + 2 * x^2) + 2 * P_2 * x * y$$
$$p_y = P_2 * (r^2 + 2 * y^2) + 2 * P_1 * x * y$$

3.4.2. **Photogrammetric procedure:** It is known that the photogrammetric works concerning the steps to be done to obtain object co-ordinates or other desired results by using the photogrammetric technique. In this study the following steps have been photogrammetrically done:
- Importing the photographs into the used photogrammetric software.
- Marking the object points in the tested photographs (the and the upper-right corner of the post's top).
- Photogrammetrically solving for the chosen photographs.
- Marking the residual error for the obtained points' co-ordinates.
- Readjusting the marked points.
- Solving the photographs once again for final solution.
- Exporting the object points' co-ordinates in ASCII format.

The previous steps have been done for different features and features percentages. Forty-nine cases have been studied to obtain the accuracy for each case. Three images of the test field (left, centre, and right) were taken using each of the used cameras in order to fulfil the required minimum number of photos for this version of the PhotoModeler software. The photos were imported and the points were marked in the left photo, and then referenced in the other two photos. Several repeats were made to achieve the best accuracy. Cameras self-calibrations were done during the photogrammetric solution to achieve the best accuracy. PhotoModeler does scaling in different ways, scale only, scale & rotate, 3 points. 3 points was used in this study . This way is assigning the scale and the system coordinates as well. A report was exported for each case for further comparison that contains the camera stations positions; the 3D space coordinates of the points, and the camera external orientation.

4. RESULTS

The results were a kind of X, Y and Z RMS against each studied feature percentage. Forty-nine projects have been done for all features, as the original photo case was a repeated project within each feature. Table (1) shows the No. of projects against each feature. Figure (4) through (11) show the relationships between the features percentages and the RMS for the applied features.

Feature	No of Projects
Re-size	7
Sharpen	7
Blur	6
Contrast	7
Brightness	7
Shadow	7
Midtone	7
Highlight	7

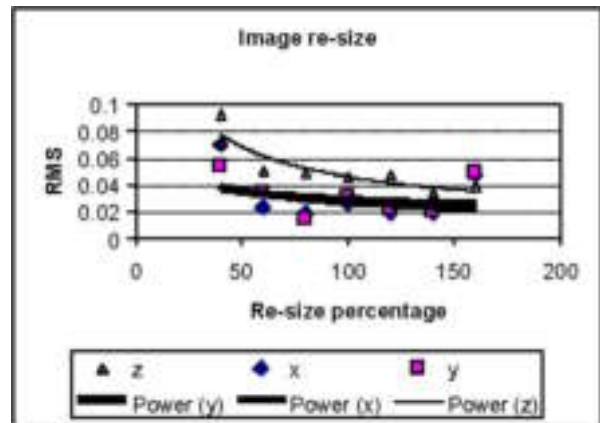Table1. No of projects against each feature

Figure 4. Relationship between the re-size percentage RMS (mm)

5.ANALYSIS

The results show that some of the studied features have effect in the close range photogrammetric measurements accuracy and some have not any effect. Resizing images to a smaller size will lead to a weak accuracy while resizing them to a larger size will lead to a higher accuracy. The improvement in the accuracy due to resizing to larger size is not that big against the file size that will be produced due to changing the image size, which can be clearly seen in Fig. (4). Sharpen images has a very small effect in improving the accuracy. Blurring images is weakening the accuracy till 20%, then the accuracy isn't affected any more by increasing the blurring percentage. Contrast, Brightness, and shadow have no effect in the accuracy, as the change in the accuracy in each case is very small and can be neglected. Applying Midtone increase the accuracy in the positive direction and decrease it in the negative direction. The accuracy decreases by increasing the highlight percentage while decreasing the highlight percentage increases the accuracy.
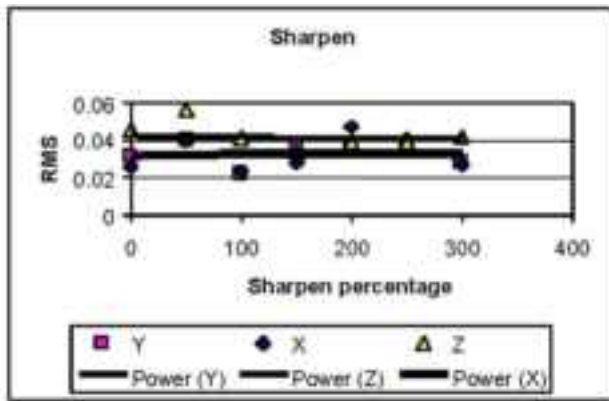
Figure 5. Relationship between the Sharpen percentage and the RMS (mm)
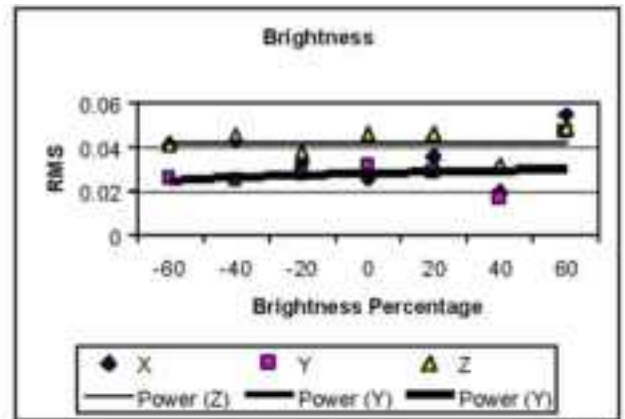

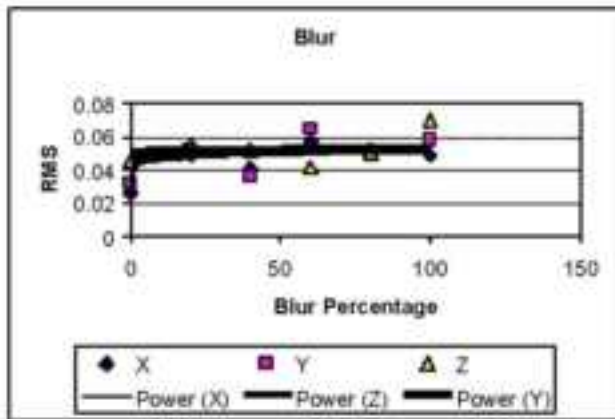Figure 8. Relationship between Brightness percentage and the RMS (mm)

Figure 6. Relationship between the Blur percentage and the RMS (mm)
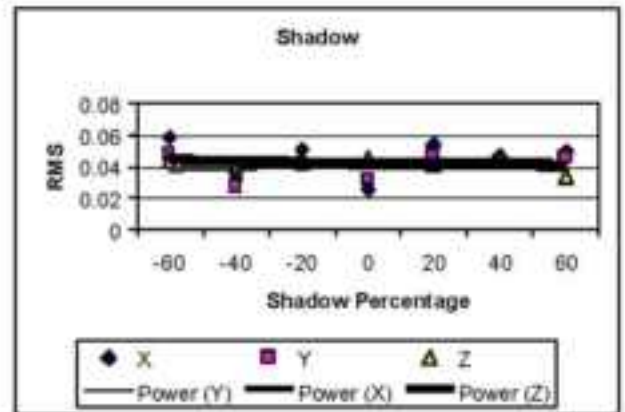

Figure 9. Relationship between the Shadow percentage and the RMS (mm)
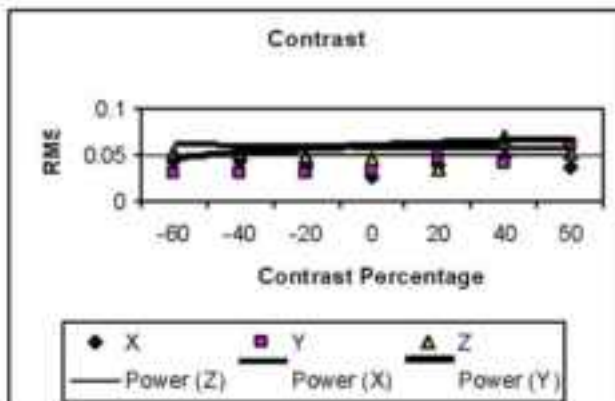

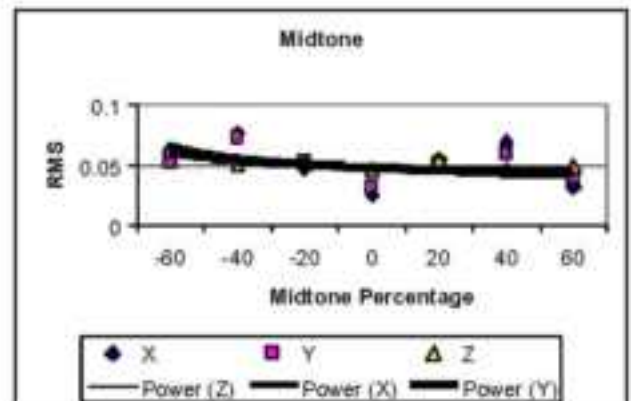Figure 7. Relationship between the Contrast percentage and the RMS (mm)

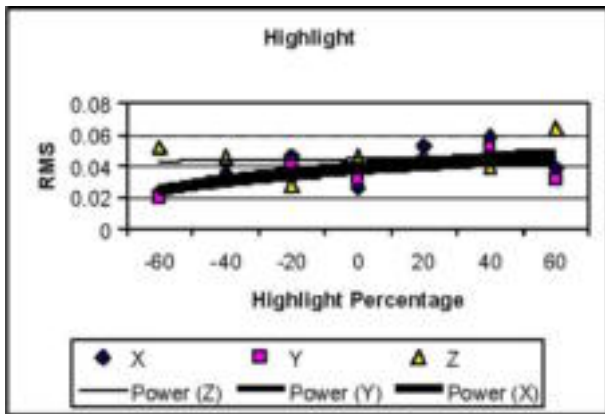Figure 10. Relationship between the Midtone percentage and the RMS (mm)

Figure 11. Relationship between the Highlight percentage and the RMS (mm)

6. CONCLUSION

Applying image enhancement features on images that will be used in further close range photogrammetric application is not always useful. Applying such feature could help in increase the images quality and give a better view for the images, but this could lead to weak measurements accuracy. From the pervious analysis we can conclude that it's better to resize the images to a higher size with taken into consideration the image file size. It's not recommended to resize the images to a smaller size as this will lead to a weak accuracy. Highlight and Midtone have effect in the accuracy in reverse way. Shadow, brightness and contrast have no effect in the accuracy at all, so applying them on images is not worse especially if this will improve the image view. Finally, we can conclude that applying the studied image enhancement feature can affect the accuracy so we should give it a concern in the scope of the results of this study.

REFERENCES

3D Studio 1996. 3D studio MAX on-line help, Yost Group Inc.

Abdel-Aziz Y. I., 1974. Expected Accuracy of Convergent Photos, Photogrammetric Engineering and Remote Sensing, Vol. 40, No. 11.

Brown D.C., 1971. Close-Range Camera Calibration, Photogrammetric Engineering and Remote Sensing, Vol.37, No. 8, pp.855-866.

Coppola F., Lo Brutto M., Midulla P. 2000, and VILLA B. Urban 3-D Models For Planing Of Mobile Telephony Systems, International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Part B3. Amsterdam.

Ebrahim M . and Farrag F. 2001. Using CAD as a New Technique in Digital Close Range Photogrammetry for Accuracy Studies, Faculty of Eng. Journal, Al-Azhar University, July.

Ebrahim M, 2000. Determination of the Islamic Art Accuracy byUsing Digital Close Range Photogrammetry, the ISPRS archive of XIXth congress, Vol. XXXIII, Amsterdam.

Ebrahim M . 1992. Using Close Range Photogrammetry for

Some Engineering Applications, M. Sc. Thesis, Assiut University, Egypt.

EOS Core Technology , 2003.

 http://www.photomodeler.com/corp 03.html, Eos Systems Inc., Canada (12.12.2004)

Fraser C. S. 1990. Film unflatness effects in analytical non-metric photogrammetry, ACSM -ASPRS Annual Convention, Vol. 5.

Hottier Ph. 1976. Accuracy of Digital close Range Analytical Restitution : Practical experim-ental and Prediction, Photogra-mmetric Engineering and Remote sensing, 42(3).

Kraus K. 1997. Photogrammetry : Advanced Methods and

Applications, Vol. 2, 4th edition, Ferd. Duemmlers Verlag, Bonn.

Manifold System, 2005. http://exchange.manifold.net/manifold/manuals/5_userman/ mfd50Image__Resize.htm, (02.01.2005)

Mikhail E. and Gracie G. 1981. Analysis and Adjustment of Survey Measurements, Van Nostrand Reinhold Vompany.

Photoshop , 2002. Photoshop version 7 on-line help, Adobe systems incorporated.

Photomodeler 2003. http://www.photomodeler.com, Eos Systems Inc., Canada (18.11.2004)

Vogtle Th. and Steinle E.2000. 3d Modelling Of Buildings Using Laser Scanning And Spectral Information, International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Part B3. Amsterdam.

Wiggenhagen M . 2002. Calibration of Digital Consumer Cameras for Photogrammetric Applications, ISPRS Commission III, Symposium 2002 September 9 -13, Graz , Austria.