International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 3, March - 2014

On Application of Image Processing: Study of Digital Image Processing Techniques for Concrete Mixture Images and Its Composition

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Abstract: **The concrete mixture is combination of various Cement, Air-voids and Aggregates. To analyze the compositions of the concrete mixture, the X-ray CT images are used. Digital image processing algorithm is applied to analyze the obtained image. Using this Digital image processing algorithm the obtained image is processed and filtered. The resultant image is compared with the X-ray CT image and the measured and predicted mixture proportions are compared to analyze the absolute errors. The threshold range T1 and T2 were found for aggregates, cement materials and air-voids. On comparing the obtained range with the predicted measurement, it is found that the Digital Image processing algorithm results better accuracy. This leads to conclude that Threshold algorithm provide significant improvement over the manual and subjective techniques used for the analysis.**

Keywords: ***digital Image Processing, Threshold Algorithm, composition of concrete mixture***

I. INTRODUCTION

Concrete mixture is used for the building construction and it is the major frame structure of any building. There are certain standards and measurements to maintain the strength of the concrete. This measurements need to be maintain for the proper structure and strength. Aggregate is composition of coarse material. It is mainly used in construction which is combination of sand, gravel, crushed stone, slag, recycled concrete etc. Aggregate serves as reinforcement to add strength to the overall composite material. Analysis of concrete mixture provides information regarding the raw material and component used. Concrete material used is consists of heterogeneous raw materials. The main components can be classified as combination of air voids, aggregates and Cement. Cement is a binding material. It is a substance that sets and hardens independently, and can bind other materials together. It is very thin material having range for 75 to 200 microns. Composition and effective strength highly depends on the air void presence and its presence. The air-void presence highly affects the performance of the concrete structure and the strength of the mixture consists of air-voids, aggregate and Cement.

Concrete mixtures have different compositions and to analyze the compositions, it is required to identify the realistic contents of concrete micro structures. Using X-ray computed tomography, the image can be obtained. It is an advanced technology which generates 2 dimensional or 3 dimensional images of very high resolution. The microstructure of concrete structure can be obtained using this technology. The composition and analysis of Concrete mixture can be analyzed using the obtained images. Various studies show the application of X-ray computed tomography. Identification of air-voids, Cement and aggregates and their proportion can be obtained using the image obtained by X-ray computed tomography.

Computed Tomography (CT) is an imaging technique where digital geometry processing can be used to generate a 3D-image of brain's tissue and structures obtained from a large series of 2D X-ray images. X-ray scans furnish detailed images of an object such as dimensions, shape, internal defects and density for diagnostic and research purposes. Digital X-ray is equipment that takes the place of a conventional x-ray film processor and produces x-rays on a monitor instead of film. There are three standard equipment types used in producing digital x-ray images. CR (Computed Radiography) equipment, DR (Direct Radiography) and CCD (Charged coupled Device) camera are the three basic types of equipment used to capture images. If the image is blurred with a function whose FT is well behaved, we should be able to construct a de-blurring function. It turns out that the 2-D FT of 1/r is 1/^{p}. Since the inverse of 1/p is | p|, then we should be able to compute the 2D FT of the blurred image, multiply the FT of the result image by | p| , and then calculate the inverse FT. This is not only one approach. There are many other approaches and different ways to view the reconstruction process. One of the most fundamental concepts in CT image reconstruction if the "Central-slice" theorem. This theorem states that the 1-D FT of the projection of an object is the same as the values of the 2-D FT of the object along a line drawn through the centre of the 2-D FT plane. Note that the 2-D Fourier plane is the same as K-space in MR reconstruction. The 1-D projection of the object, measured at angle ϕ, is the same as the profile through the 2D FT of the object, at the same angle. Note that the projection is actually proportional to exp ($\int u(x)xdx$) rather than the true projection $\int u(x)xdx$, but the latter value can be obtained by taking the log of the measured value. CT image reconstruction is possible using "Central-slice" theorem.

This theorem is based on the concepts that 1-D FT of the projection of an object is the same as the values of the 2-D FT of the object along a line drawn through the centre of the 2-D FT plane. Note that the 2-D Fourier plane is the same as K-space in MR reconstruction.

II OBJECTIVES

(i)To identify the composition and proportion of air-voids, Cement and aggregates of the concrete structure.
(ii)Comparing the measured and actual obtained results by analyzing volumetric driven threshold properties of compositions of concrete structure.

A. *Experimental Data* : Pre processed image used for the image process experiment is is an image obtained using X-ray CT images for Texas DOT funded study (Alvarado et al., 2007). The sample image was prepared by the University of Texas-El Paso. The X-ray CT scanning took place at Texas A&M University. The aggregate source used was hard limestone (HL) and only one binder grade PG 76-22 was utilized to prepare the mixture. The gyratory compacted specimen (150 mm diameter by 165 mm height) was cored and sawn to a diameter of 100 mm and a height of 150 mm. The AC core was scanned perpendicular to its vertical axis.

III METHODS & METHODOLOGY FOR IMAGE ENHANCEMENT:

To obtain the Concrete structure image, micro focus X-ray tube having 320kV measure is used. Obtained image is analyzed using MATLAB ® environment. The gray scale image is processed to obtain boundary intensity of the concrete compositions. The composition's volumetric information is obtained by analyzing the intensity of aggregates, cementing material and air-voids. Image processing of obtained X-ray image is performed in three stages. First stage involves edge detection and filtering process of original image by applying different edge detection techniques in process to obtain the best result. The second stage involves contrast enhancement of the image obtained by applying the first step. The final stage involves de-noising the obtained image from stage-2. It is further analyzed to obtain the segments of concrete compositions.

A. Edge detection and filtering:

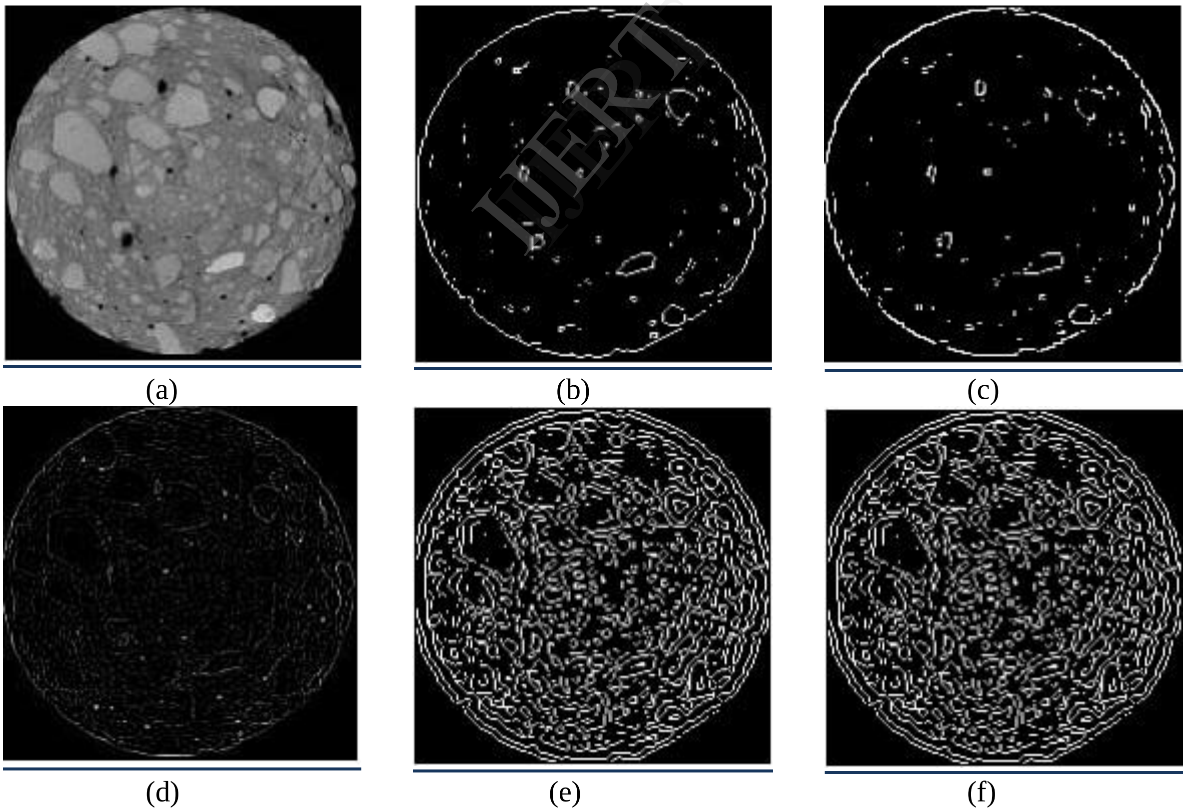


Figure 1. X-ray CT image enhancement; (a) Original Image (b) Image obtained after applying Sobel edge detection (c) Image obtained after applying Roberts edge detection (d) Image obtained after applying Laplacian filtered image and log filter (e) Image obtained after applying Log edge detection filter (f) Roberts edge detection filter.

Obtained images of concrete structure using X-ray CT are gray scale images. Pixel value is ranging from 0 to 255. Enhancement of image is obtained by applying contrast enhancement and removal of noise. Figure 1a shows the original image obtained using X-ray CT technique. This original image is of resolution 512x512 and having resolution of 185 microns/pixel. This image is further enhanced by applying noise filtering with laplacian filter and then analyzing edge with log filter. Figure 1b shows the Sobel edge detection filter image. Figure 1c is obtained using Roberts edge detection filter. This is applied on the original image. Figure 1d depicts the obtained image from the original image after applying unsharp filter and then Laplacian filter. Figure 1e is obtained on applying Log edge detection filter on the image obtained using 1d. Figure 1f is result of Roberts edge detection filter.

It is observed that the resultant image obtained on applying filters, the contrast level is comparatively not effective. To obtain higher quality of image, histogram equalization is applied. The obtained image is generated where the intensity of image pixels are evenly distributed.

B. Pre-processed Image Segmentation:

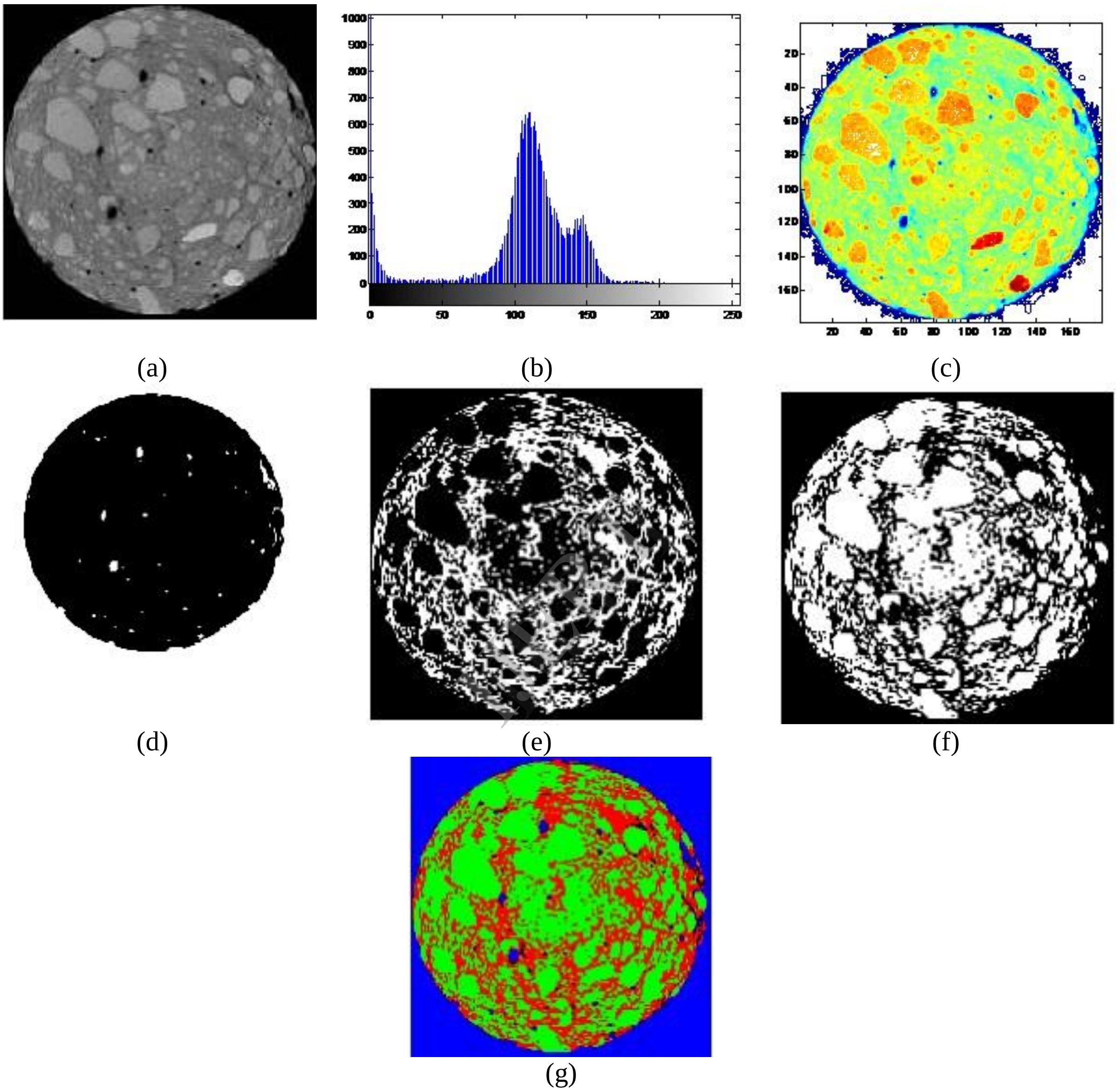


Figure 2. Applying Segmentation on Original Image; (a) Original Image (b) Histogram of original image shows distribution of intensity (c) Obtaining equally spaced contour levels with n=128 (d) Segmentation of Air voids with intensity <60 (e) Segmentation of Cement having intensity between 60 to 110 (f) Segmentation of aggregates having intensity range above 110 (g) RGB representation of combined segmented portions of original image.

Original image of X-ray CT is further processed. Histogram is obtained for the original image which displays the distribution of intensity of original image. Figure 2c shows is obtained by equally spaced contour having levels with n=128. It clearly shows segments of Air-voids, Cement and Aggregates. Further the Air-voids are segmented which is obtained having pixel intensity <60. Figure 2d depicts the Air-void segmented portion. Cement parts are the portion having the range of intensity between 60 and 110 which is shown in Figure 2e. The aggregates are segmented for intensity above 110 and shown in Figure 2f. The Air-voids, Cement and aggregates are represented in Figure 2g which is RGB representation of the original image. The blue portion of the image depicts the Air-voids part whereas the red and green part represents Cement and aggregates respectively.

Images are represented using Figure 2b shows the enhanced image using histogram equalization. Concrete structure X-rayed CT images include a variety of types of noise. Its main sources are sensor quality, as well as image digitizing and pre-processing. Variations in densities within the individual Cement and aggregate also contribute to image noise. Reducing image noise is essential to obtain enhanced image quality. Median filtering is used to de-noise the concrete structure image and the kernel value is ranging from 3x3 to 9x9. The obtained result is de-noised and it is clearly visible between the original image and the obtained image in terms of contrast and clarity.

C. Contrast Enhancement of Image:

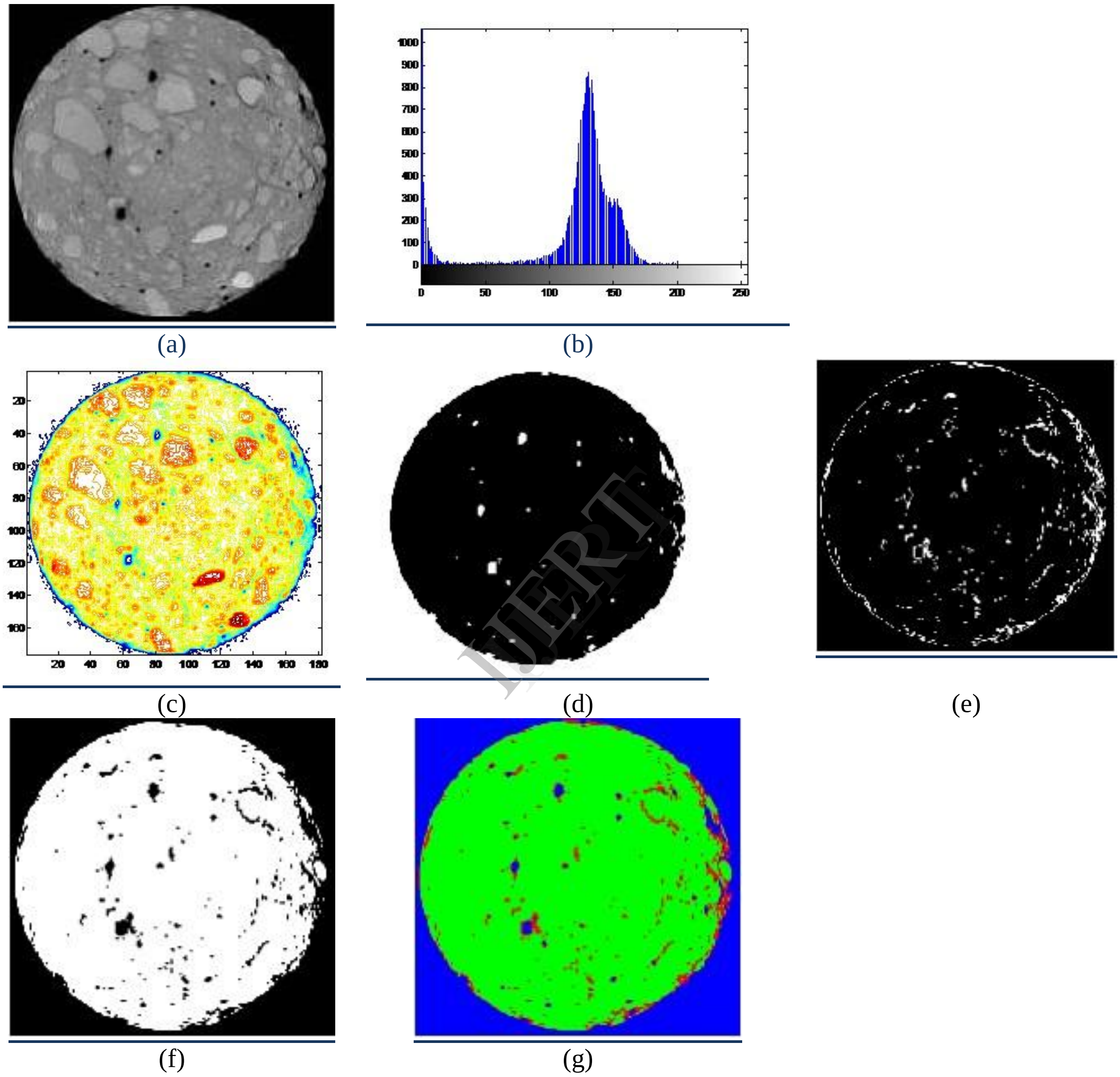


Figure 3. Contrast enhanced image. (a) Enhanced image obtained (b) Histogram of Contrast Enhanced Image (c) Equally spaced contour image (d) Segmentation of Air-voids (e) Segmentation of Cement material (f) Segmentation of aggregates (g) RGB representation of combined segmented portions of original image.

D. De-noising Image:

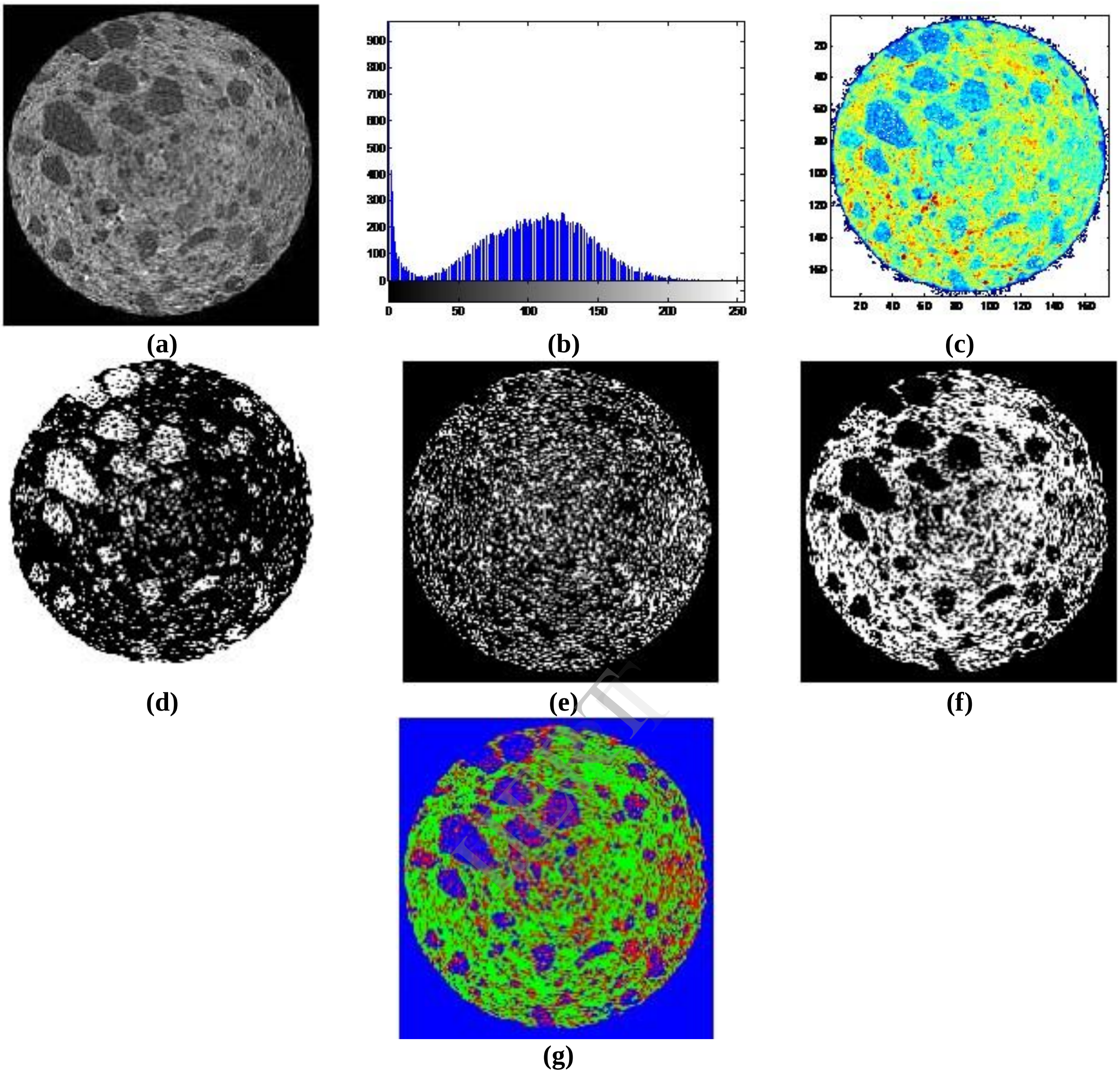
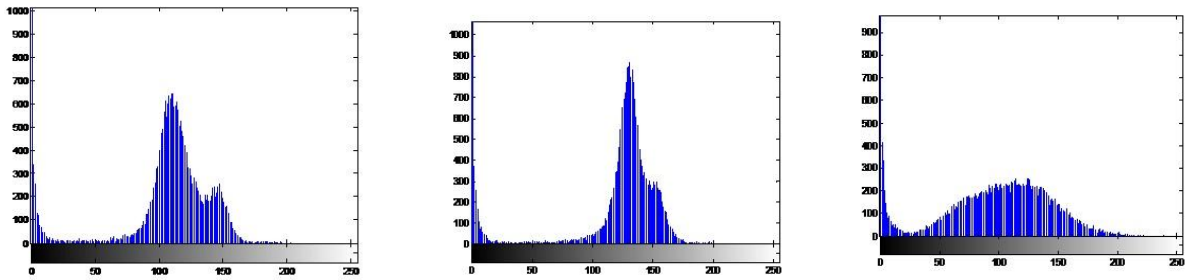


Figure 4. De noised image**.**(a) Image obtained after de-noising (b) Histogram of De-noised Image (c) Equally spaced contour image (d) Segmentation of Air-voids (e) Segmentation of Cement material (f) Segmentation of aggregates (g) RGB representation of combined segmented portions of original image.

By de-noising the contrast enhanced image evenly distribute the pixel intensity in case of aggregates, cement portion and air-voids. The histogram has shown in 4b shows results which clearly depict the distribution of pixel intensity. The segmented portion of air-voids, cement portion and aggregates in figure 4d, 4e and 4f respectively shows more clear and better enhanced and visible segmented area. Pre-filtered and de-noised image and obtained filtered and de-noised images have significant difference and is clearly visible.

E. Histograms Analysis of 3 stages:



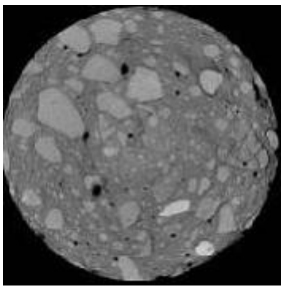
(a) **(b)** **(c)**

Figure 5. (a) Histogram of unprocessed image. (b) Contrast enhanced image histogram (c) De-noised image histogram.

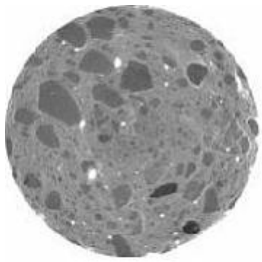
The comparative histogram in Fig.5 shows the distribution of pixel intensity. Fig.5a shows the intensity distribution of original image. Fig.5b and 5c shows distribution of intensity after contrast enhancement and de-noised image respectively. Variations in densities within the composition of concrete structure image are due to image noise. Reducing image noise is essential in obtaining enhanced image quality. For removal of noise from the contrast enhanced image, one of the very effective filtering methods is Median filtering. This method is applied for de-noising the noise effect from the contrast enhanced image. However, it does not remove the noise completely but can certainly reduce it. By applying median filtering, the gray level of each pixel is replaced by the median of the gray level of all pixel values in the pixel's neighbourhood

IV. ANALYSIS OF PROCESSED IMAGES AND SEGMENTATION:

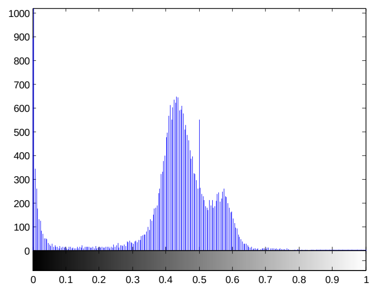
Pre-processed image is processed in three stages. First stage is applying edge-detection techniques to analyze the best possible edge detection technique to be applied for the processing in this case. The compositions are further segmented to obtain and compare the results. Second stage is contrast enhancement of image. The clarity in terms of composition segmentation is better obtained by this process. Third stage is removal of noise by applying filters. These three steps are compared in two ways: (i) Composition comparison in terms of segmentation and (ii) histogram comparison of each stage.



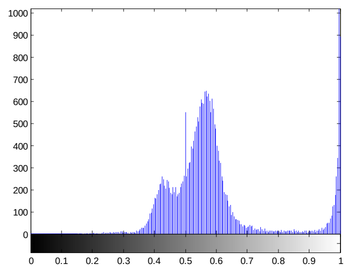
(a)



(b)

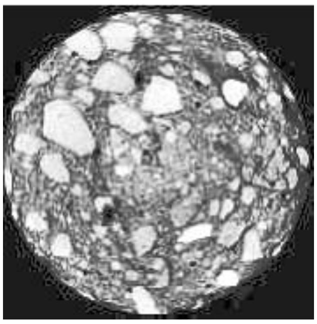


(c)

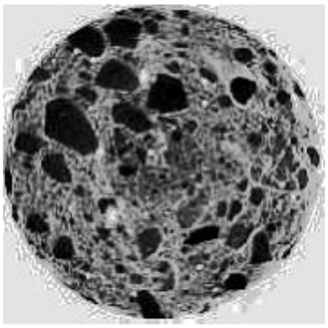


(d)

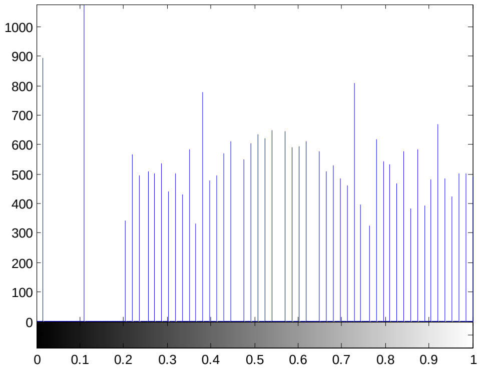
Figure 5. (a) Processed Image (b) rgb adjusted image (c) histogram of processed Image (d) histogram of rgb adjusted image



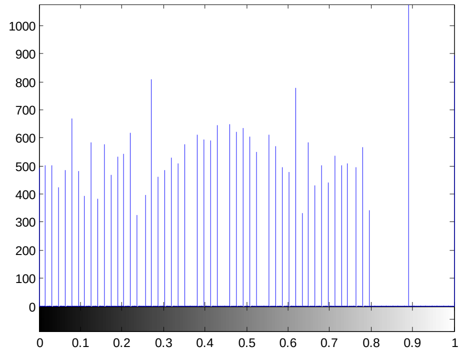
(a)



(b)



(c)



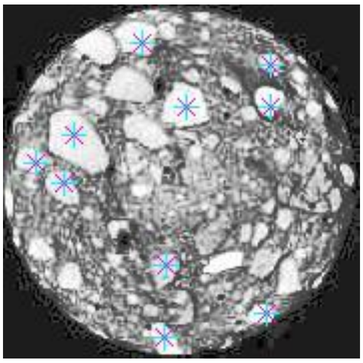
(d)

Figure 6. (a) Equalized Processed Image (b) Equalized adjusted Processed Image (c) Histogram of Equalized processed Image (d) Histogram of Equalized adjusted Processed Image

Processed image shown in Figure 5 is adjusted which is shown in Figure 5a and 5b. Both processed image and adjusted processed images are equalized. The resultant images are shown in figure 6a and 6b. Histograms of these resultant images are shown in figure 6c and 6d. It is evident that the intensity of images is equally distributed.

A. Obtaining pixel intensity for compositions:

On obtaining the equalized processed image, the final step is to obtain threshold values for the concrete structure compositions. The volumetric distribution can be identified using the threshold values of all three compositions. The threshold value is identified using the intensity of pixels obtained for aggregates, air-voids and cement material. Three steps are used to identify the threshold values of compositions. First step is to identify pixel intensity of concrete compositions:



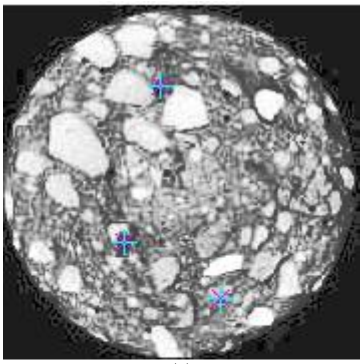
(a)

vals =

0.9365	0.9365	0.9365
0.9841	0.9841	0.9841
0.8730	0.8730	0.8730
0.9841	0.9841	0.9841
0.9841	0.9841	0.9841
0.9365	0.9365	0.9365
0.9841	0.9841	0.9841
0.8730	0.8730	0.8730
0.9365	0.9365	0.9365
0.9524	0.9524	0.9524

(b)

Figure 7: (a) Marked image to obtain pixel intensity of Aggregates (b) Pixel intensity obtained for Aggregates.

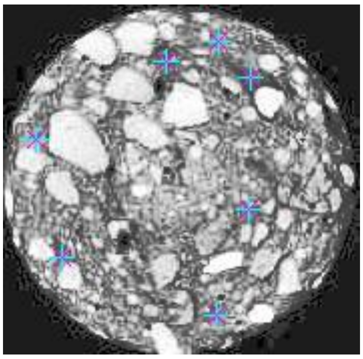


vals =

0.2222	0.2222	0.2222
0.2222	0.2222	0.2222
0.2540	0.2540	0.2540

(a) (b)

Figure 8: (a) Marked image to obtain pixel intensity of Air-voids (b) Pixel intensity obtained for Air-voids.



0.5714	0.5714	0.5714
0.6508	0.6508	0.6508
0.6508	0.6508	0.6508
0.7302	0.7302	0.7302
0.4127	0.4127	0.4127
0.4762	0.4762	0.4762
0.3492	0.3492	0.3492

(a) (b)

Figure 9: (a) Marked image to obtain pixel intensity of Cementing material (b) Pixel intensity obtained for Cementing material.

Thresholding for three compositions is obtained from the obtained pixel intensity shown in Figure 7 , 8 and 9. Image threshold denotes the gray scale level boundary. The threshold separates three compositions named air-voids, cement and aggregates.

B. Finding Threshold max and min for compositions:

On obtaining RGB intensity of compositions, the next step is to identify the threshold value for individual compositions. T_{min} and T_{max} for aggregates, air-voids and cement composition is obtained as second stage of the process. Obtained T_{min} and T_{max} are of the range 0 to 1 and need to convert on equivalent 0 to 255 scales.

	T_{Min}	T_{Max}	Range
Aggregates	0.8730	0.9841	0.1111
Air-Voids	0.2222	0.2540	0.0318
Cement	0.3492	0.7302	0.3810

Table-1: Threshold values for composition on scale 0 to 1.

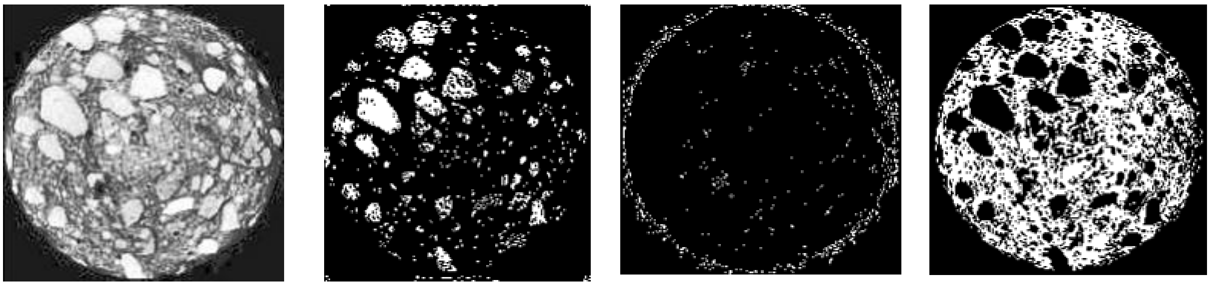
Next step is to obtain the T_{min} and T_{max} for the range 0 to 255. Equivalent range is obtained from scale 0 to 1 to 0 to 255. It is shown in Table-2.

	T_{Min}	T_{Max}	Range
Aggregates	222.615	250.9455	28.3305
Air-Voids	56.661	64.7700	8.1090
Cement	89.046	186.201	97.155

Table-2: Threshold values for composition on scale 0 to 255.

C. Volumetric composition analysis for Threshold range:

The threshold values obtained for concrete compositions are further used to obtain the segmentation. Figure 10 shows the segmentation obtained by using the Threshold values of respective compositions. It clearly indicates the proportion of aggregates, air-voids and cementing material available in the processed image obtained through X-ray CT image.



(a) (b) (c) (d)

Figure-10. (a) Processed Concrete structure image (b) Segmentation of Aggregates (b) Segmentation of Air-voids (d) Segmentation of Cement material.

As mentioned in Figure 10, the segmented propositions are segmented based on the Threshold values for respective compositions obtained. Volumetric distribution for Aggregates as shown is Figure 10b is within the range of T_{min}=222 and T_{max}=250. In case of air-voids the distribution of pixel is within the range of Tmin=56 and Tmax=65 as shown in Figure10c and cement material is within the range of Tmin=89 and Tmax=187 as shown in Figure 10d.

Composition	**Segment Pixel Range**	**Pixel Intensity**	**% Composition**
Aggregates	222>= P_x <=250	6035	31.50%
Air-Voids	56 >= P_x <=65	1057	5.52%
Cement material	89>= P_x <=187	12067	62.98%

Table-3. Volumetric % Composition of Aggregates, Air-Voids and Cement material.

Final step is to find the composition's relative proportion. Table-3 depicts the % relative composition of Aggregates, air-voids and Cement material. The ratio of Aggregates and Cement material is 33.34:66.66.

V. CONCLUSION:

Process applied to obtain the composition's relative proportion of Aggregates, Air-voids and Cement material is consists of four steps. Volumetric composition is obtained using edge detection, contrast enhancement and de-noising in sequence. Processed image is used to segment the compositions. The range of pixel intensity is found for aggregates, air-voids and cement material to acquire % relative composition. The result shows the ratio of aggregates and cement material is of proportion 33.34:66.66 which is compared to the estimated proportion. Deviation among estimated and measured composition is measured. Aggregates are deviated by +1.34% from estimated and cement material is deviated by -0.84%.

VI. ACKNOLEDGEMENT:

For the purpose of image analysis of concrete composition, the pre-processed image of concrete structure is obtained using X-ray CT images by Dr. Eyad Masad and Dr. Soheil Nazarian of Texas A&M University and University of Texas-El Paso respectively. This paper is purely analyzing the image compositions using four stages of developed algorithm. I also acknowledge my guide Dr.Jagdish Pandya for his valuable suggestions.

VII. REFERENCES:

1. Al-Omari A., Masad E. 2004. Three dimensional simulation of fluid flow in x-ray CT images of porous media. International Journal for Numerical and Analytical Methods in Geomechanics, 28, pp. 1327-1360.
2. Chandan C., Sivakumar K., Masad E., Fletcher T. 2004. Application of imaging techniques to geometery analysis of aggregate particles. Journal of Computing in Civil Engineering, 18 (1), 75-82.
3. F. Meyer, S. Beucher, Morphological segmentation, Journal of Visual Communication and Image Representation 1 (1) (1990) 21–46.
4. Y. Cheng, Mean shift, mode seeking, and clustering, IEEE Transactions on Pattern Analysis and Machine Intelligence 17 (8) (1995) 790–799.
5. D. Comaniciu, P. Meer, Mean shift: a robust approach toward feature space analysis, IEEE Transactions on Pattern Analysis and Machine Intelligence 24 (5) (2002) 603–619.
6. C. Christoudias, B. Georgescu, P. Meer, Synergism in low level vision, in: Proceedings of the International Conference on Pattern Recognition, vol. 4, 2002, pp. 150–155.
7. Q. Luo, T.M. Khoshgoftaar, Efficient image segmentation by mean shift clustering and MDL-guided region merging, in: IEEE Proceedings of the International Conference on Tools with Artificial Intelligence, November 2004, pp. 337–343.
8. J. Wang, B. Thiesson, Y. Xu, M.F. Cohen, Image and video segmentation by anisotropic Kernel mean shift, in: Proceedings of the European Conference on Computer Vision, Prague, Czech Republic, vol. 3022, 2004, pp. 238–249