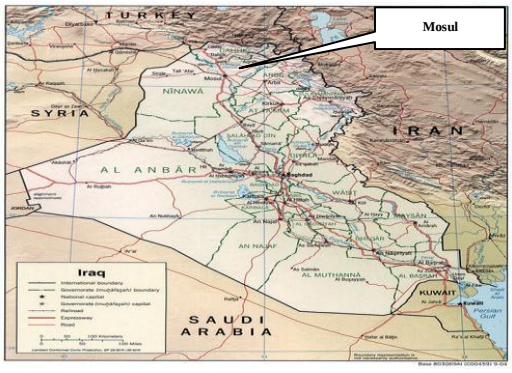
Detection Depth of Mosul Dam Reservoir by Using Image Processing Techniques

Mohammed Faozy Omer Khattab , Fatin Aziz Mustafa Al-Ani
Department of image processing, Remote Sensing Center, University of Mosul, Mosul, Iraq
(**Received:** 29 / 11 / 2010 ---- **Accepted:** 16 / 3 / 2011)

Abstract
The remote sensing techniques can be used for more quantitative studies in water management and monitoring. This occurs when, these techniques are connected with GIS programs. In the current study, (ETM+) images have been used to estimate water depth of Mosul Dam's Reservoir that is located North of Iraq and specifically north of Mosul city (40 Km). By applying multispectral image processing techniques that are associate with GIS programs, through using of Matlab 7.5, ERDAS 8.4, Arc View 3.2 and Glober Mapper 7 programs. When applied the algorithm of the processing showed that the band 1 and band 5 are suitable for this study, and the (.ras) format for image have increase of pixel dimension and as well the pattern distribution of pixel intensity give more details at low gray levels, and the value of threshold 0.985 are very necessary to success of entropy filter work. Results of application of linear model's were shown as map of depth distribution started from 0 to 80 meters. Where the shallow and moderate depth (>60m) were take up south part's of reservoir, while the deep water (<60m) take up middle and upper part's of Mosul reservoir.

Introduction
Remote sensing techniques can be used for water monitoring, the satellites images are consider one of remote sensing data which provides both spatial and temporal information. These information are very important to understand changes in water body parameters, which is necessary for developing better management.The depth of water presents one of a dynamic body water parameters which are effect on real distribution and characteristics of body, water hydraulics, modeling flow dynamic, and forecasting flow hazard (Fonstad and Marcus, 2005). In the current study, image processing techniques have been used to detect water depth of Mosul dam reservoir, which is located north of Mosul city (40 Km), figure(1), it was filled with water since 1986 at Tigris river valley. The surface area of reservoir equal to 385 km^2, the elevation equal to (330 m) above sea level, rounded by coastline of 168 Km, and the capacity of storage $11.11x10^9$ m^3(Al-Hamdani,2007).This search is represented with sequential steps of Image processing techniques which are used , assisted by Matlab 7.5, ERDAS 8.4 and Arc view 3.2 programs, that have been implemented on ETM^+ bands which was captured in(2002) to obtain resultant image suitable for spatial and spectral domain, with more accurate to get an acceptable depth of Mosul dam reservoir measurement.



Figure(1) : Map showing location of Mosul reservoir

Data and preprocessing
The current research algorithm require types of data source and preprocessing operations on this data to become more suitable for application of this algorithm. The Main data source represented by satellite images which are obtained by enhancement thematic mapper (ETM^+) that is carried on landsat7 satellite. The table (1)shows properties of bands that were used in this study.

Table(2):Informations of used maps

Map name	Date	Scale	No. of map index
Dohuk	1985	1:100000	J-38-S-NE
Dohuk	1980	1:100000	J-38-S-NE
Rabiah	1988	1:100000	J-38-S-NW

The digital elevation models(DEM) for Mosul dam reservoir was also used as elevation reference for study. The DEM file obtained from Shuttle Ruder Topography Mission(SRTM) with 90m resolution from USGS. As well as topographic maps are used, that was obtained from Military Survey Office. Table(2) shows information of each used map.

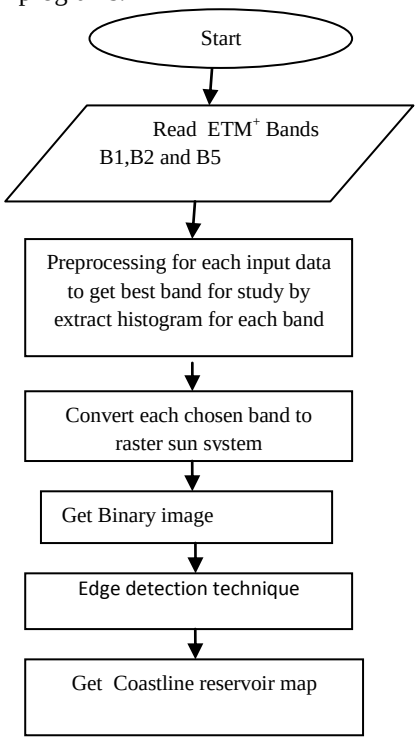
Table(1):Properties of ETM^+ chosen bands

Date	Band No.	Spatial Resolution(m)	Spectral Band Range(μm)
2002	1(Blue)	30x30	0.450-0.515
2002	2(Green)	30x30	0.525-0.605
2002	5(Middle IR)	30x30	1.55-1.75

The preprocessing steps that have been applied in this study consisted first by using subset the image of study area from original satellite image of chosen bands by using ERDAS program to have suitable size for processing algorithm steps, and then cropping the area of study. Scanner type (A_0)high resolution used to digitize the topographical maps and use the ArcView program to do georeferencing of maps.

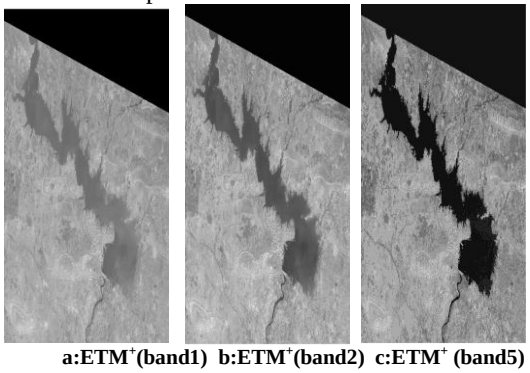
Coastline Extraction
Separation of water body using remote sensing data is important for measurement characteristics of water resources (Shahraini, et.al., 2003). Coastline represent line separate between land and water mass , which is consider as the base feature to obtain information about orientation and geometric shape for land and

water (Liu and Jezek, 2004).There are various image processing methods for detection and extraction coastline depending on the purpose of study. In current study multi image processing techniques have been used to detect coastline of Mosul dam reservoir, and then accurate determination this line spatially, as shown in the flow chart, figure (2). These techniques have been of using Matlab 7.5, ERDAS 8.4 and Arc view 3.2 programs.



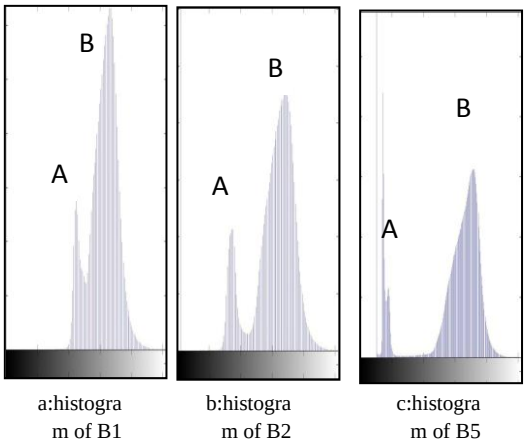
Figure(2) : Flow chart of coastline Mosul reservoir detection

First step, satellite images of thematic mapper (ETM^+)Bands B1, B2and B5 as shown in figure(3), which represent the best bands for water study (Jensen, 2007), were entered to execute practical steps for detecting coastline. Then choose best band that suitable to this purpose, by using the histogram of gray levels, where the peaks in histogram correspond to dominant types of land cover in the image(Jensen, 2005The histogram of B5 as shown in figure(4), shows two dominate land cover classes which are represent water(A) and land(B) as a sharp double peak curve, while the histogram of B1and B2 have smooth peak between the two same classes.



a:ETM^+(band1) b:ETM^+(band2) c:ETM^+ (band5)

Figure(3): Original chosen bands

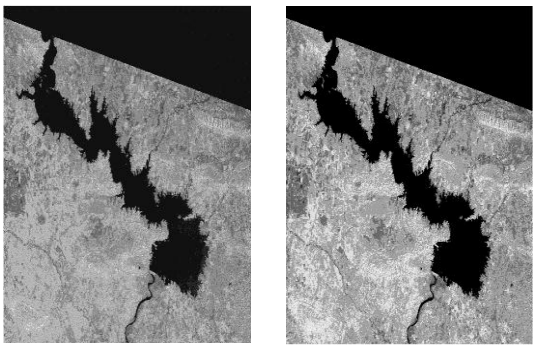


a:histogram of B1 b:histogram of B2 c:histogram of B5

A: water , B: land

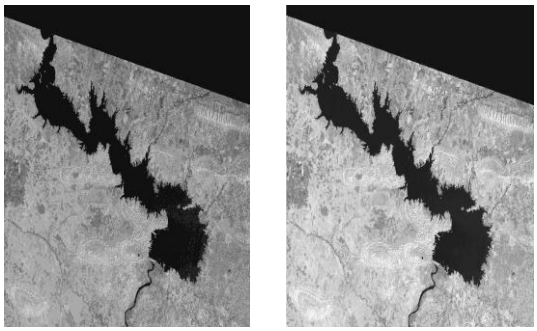
Figure(4):Histogram of chosen bands

The band 5 is best for extraction land and water interface, and also it exhibits a strong contrast between land and water features due to the high degree of absorption of mid infrared energy by water, even the turbided water(Alesheikh and et. al., 2007). The operation of coastline of Mosul reservoir detection require to access and accurate of image pixels characteristics in brightens and spatial resolutions , so to obtain this properties of entered image, The entered image converted from its original format(.tiff) to Sun Raster format(.ras) by using ERDAS program.The Sun Raster format is the native bitmap with simple distribution of pixels (Wikipedia, 2009). Also this format can give availability to detect the changes of terrain and the ground resolution of the image data with clear intensity of pixels (Jensen ,2005) comparing with others format as (bmp), figure(5). As well the pattern distribution of pixel intensity in Sun Raster format give more details at low gray levels (GL) compare with others format (.tiff), figure(6).

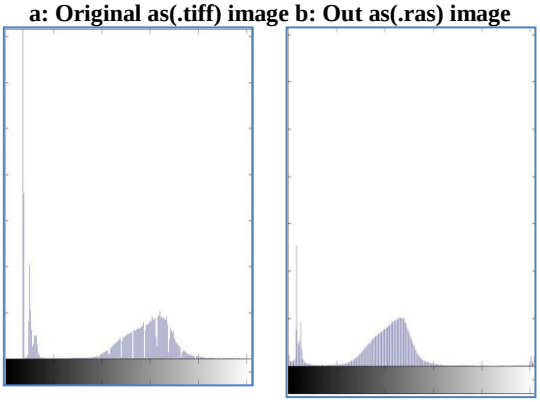


a: Original as(.bmp) image b: Out as(.ras) image

Figure(5):Output raster image from input (.bmp) image



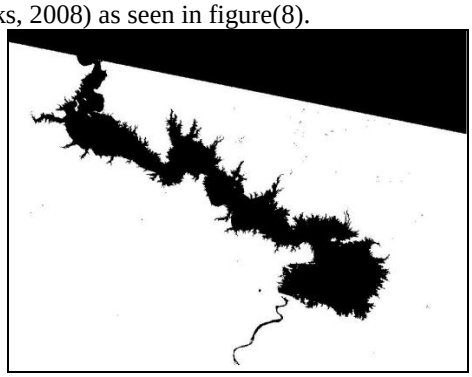
a: Original as(.tiff) image b: Out as(.ras) image



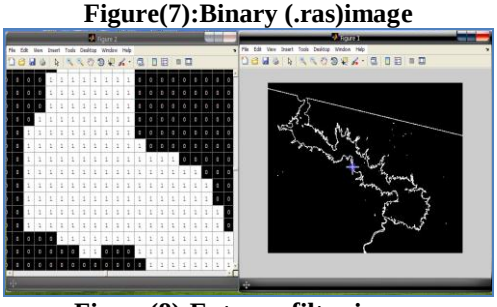
c :Histogram of original image (.tiff) d:Histogram of raster image

Figure(6): Convert original tiff image to sun raster format

In the next step, the gray image converted to binary image by Matlab program instructions, in order to isolate the water of the land. Where the value of (0) represent water and (1) represent land(Jenson, 2005), as shown in figure(7). Spatially, we extract Mosul reservoir boundary by use entropy filter method, that is led to deal with gray scale of binary image(Math Works, 2008) as seen in figure(8).

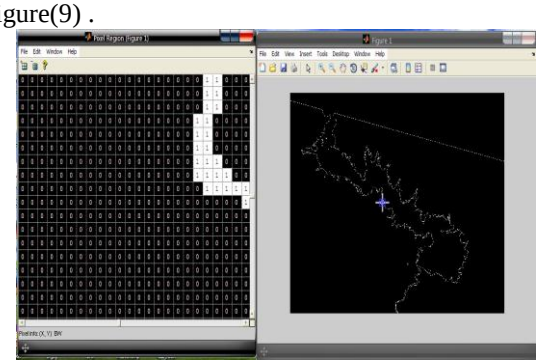


Figure(7):Binary (.ras)image



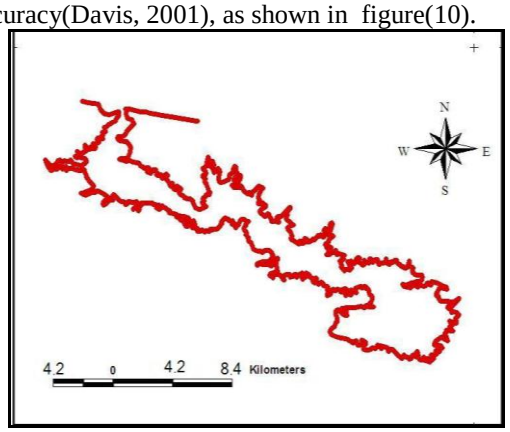
Figure(8):Entropy filter image

This figure reflect that the overlap area between water and land is wide, so to obtain fixed boundary we chose arbitrary threshold value (0.985), This value is multiplied by each pixel value of previous image as next step to extract Mosul coastline reservoir, figure(9) .



Figure(9):Entropy filter image with threshold

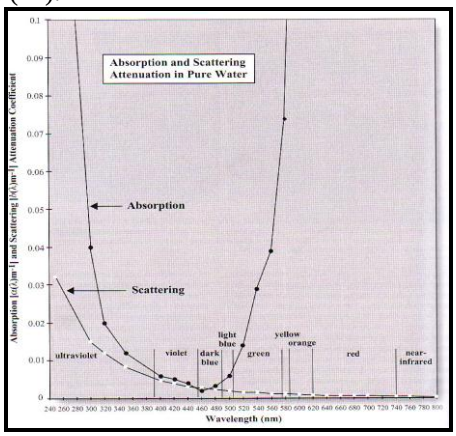
Finally, convert last output resultant image to vector format by using ArcView3.2 program, to get more realistic image that have better spatial accuracy(Davis, 2001), as shown in figure(10).



Figure(10): Coastline Mosul reservoir map

Depth Detection of Mosul Reservoir

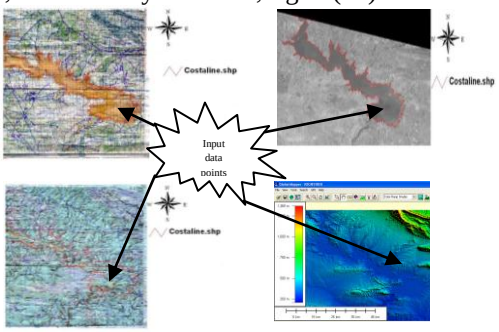
The spectral reflectance of water differs with wavelength, due to natural of interaction between energy and matter, (Daghastani, 2003). This different reflectance of wavelength with water is shown in figure (11).



Figure(11): Absorption and scattering of light in pure water(Jenson, 2007)

The optimum optical wavelengths to obtain depth information are from approximately 0.44 to 0.54µm based on the previous figure. So this range of wavelength represents band1 on Landsat Thematic Mapper sensor system, which is often called the

water penetration band (Jenson, 2007). A Linear regression model has been applied for calculate depth of water in Mosul reservoir, where the reflection intensity of single band indicates the depth of water (Xinghua., 2008). The boundary or border of this model was taken from the previous section (coastline Mosul reservoir map), and the input data points have been taken from collection data of topographical maps before and after building Mosul Dams, DEM files, and intensity of band1, figure(12).



Figure(12): Method of collection input data points

These points used into linear regression model to estimate depth of water from intensity of band 1 as follows:

$$D_{i,j} = 162.857 - 285.714\ G_{i,j}$$

Where:

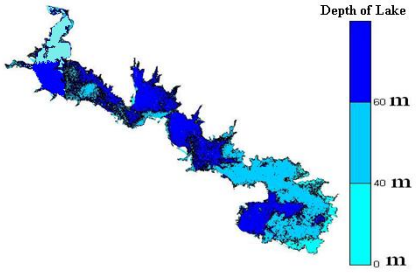
D = Depth of Mosul reservoir (m).

G = Intensity of band 1.

i= X coordinate.

j = Y coordinate.

Note that the correlation coefficient of this equation is 0.88 , Results of model is shown in figure (13) where appear the shallow depth water(0-40m), moderate depth (40-60m), and deep water more than (60m). The results as show in figure 13 where the Mosul Reservoir be classified as shallow water (0-40m), moderate (40-60m), and deep water (over 60m).



Figure(13): Depths of Mosul reservoir from regression models

Conclusion

The remote sensing can be good instrument to get new useful sides of water managements and monitoring. This occur by applying sequential steps of image processing techniques which unite with GIS programs. In the current study , b1 and b5 for satellite Bands of enhancement thematic mapper (ETM+), are very suitable for depth estimation of Mosul reservoir after application of image processing operations. Using the (.ras) format had gave more detect for coastline of the reservoir through increasing dimensions of image pixel compare with others formats. The threshold value 0.985 in this research was improve effectiveness of entropy filter with more specific delineation of coastline of reservoir. The linear regression model's was appropriate to estimation of reservoir depth from one band intensity, the lower part of reservoir represent shallow to moderate, where the sediments accumulation in this part and level of land approximate to water level of reservoir while the upper and middle parts of reservoir in addition to front of dam represent deep water in the reservoir. Results application of linear model's were as map of depth distribution started from (0) to more than (60) meters. The results are more accurate if the information about values of water depth by use GPS ,turbidity and amount of algae are measured at the same date as the acquisition of satellite images

References

1. Alesheikh, A. A., Ghorbanali, A., and Nouri. N., 2007: Coastline Change Detection Using Remote Sensing. Int. J. Environ. Sci. Tech., 4 (1): 61-66pp.

2. Al-Hamdani, Adil.A.B., 2007:Distribution of some Physical and Chemical Parameters and its Seasonal Variation in Mosul Dam Reservoir. The first Scientific Conference of Environment and Pollution Control Research, Mosul University 5-6 June 2007, 45-55pp.

3. Daghasani, Nabil, S., 2003: Remote Sensing, Principle and Application. Dar Al Manaheg, 472P.

4. Davis, B. E., 2001:GIS: A Visual Approach ,2nd edition, IS BN-B Press, 438P.

5. Fonstad, M. A. and Marcus' W. A., 2005 : Remote Sensing of Stream Depths with Hydraulically Assisted Bathymetry (HAB) Models. Geomorphology, Vol.72, No.4,pp. 320-339.

6. Jensen J. R., 2005:Introductory Digital Image Processing ,A Remote Sensing Perspective, 3rd., Pearson Prentic Hall Inc, 526P.

7. Jensen J. R., 2007: Remote Sensing of the Environment :An Earth Resource Perspective ,2nd., Pearson Prentic Hall Inc, 592P.

8. Jerry C.Ritchie J. and edikon C. M.Cooper, 2000: Remote Sensing Techniques for Determining Water Quality: Applications on TMDLs , Hydrology and Remote Sensing Laboratory and National Sedimentation Laboratory.

9. Xinghua., Le, Fan, Zhewen., Fang, Yu., and Zhang, Yun., 2008: Using TM Image to Estimate The Quantity of Sand Sediment in Poyang Reservoir: A Case in Nanji Xian Vilage. The International Archives of the Photogrammetry, Remote Sensing

and Spatial Information Sciences. Vol. XXXVII. Part B8. Beijing, 795-804pp.

10. Liu, H and Jezek, c.k., 2004: Automated Extraction of Coastline from Satellite Imagery by Integrating Canny Edge Detection and Locally Adaptive thresholding methods, International Journal of Remote Sensing ,Vol.25,Issne 5,937-958 PP.

11. Math Works, 2008:Matlab Tools, Image Processing Tool Box ,Version 7.6.

12. Shahraini, H. T., Jajrishi, M., Alimohammadi, A., and Abrisharmch, A., 2003: Spatial Extent Mapping of Reservoirs and Coastal Wetland using Multispectral Images. Environmental and water Research center , Tehran , Iran

13. Wikipedia, 2009 :Raster Graphics – Wikipedia , The Free Encyclopedia ,Availableat: wikipedia .org /wiki/ Raster _ graphis.

تقدير عمق بحيرة سد الموصل باستخدام تقنيات المعالجة الرقمية

محمد فوزي عمر خطاب ، فاتن عزيز مصطفى العاني

قسم المعالجة الرقمية ، مركز التحسس النائي ، جامعة الموصل ، الموصل ، العراق

(تاريخ الاستلام: ٢٩ / ١١ / ٢٠١٠ ---- **تاريخ القبول:** ١٦ / ٣ / ٢٠١١)

الملخص

إن تقنيات التحسس النائي ممكن ان تستخدم في دراسات اكثر كمية في مجال ادارة ومراقبة المياه. ويحدث هذا عندما تترابط هذه التقنيات مع برامج نظم المعلومات الجغرافية (GIS).في الدراسة الحالية استخدمت مرئيات من نوع (+ETM) في تقدير عمق مياه بحيرة سد الموصل الواقعة شمال العراق وبالتحديد حوالي (40)كم شمال مدينة الموصل. عن طريق تطبيق عدة تقنيات معالجة الصور المترابطة ببرامج الـ(GIS)، من خلال استخدام برامج الماتلاب(Matlab 7.5)، الايرداس (ERDAS 8.4)، الارك فيو(Arc View 3.2)، و الكلوبر مابر(Glober Mapper 7).

عند تطبيق خوارزمية المعالجة ظهر بان الحزمة الأولى والخامسة من حزم هذا المتحسس تكون ملائمة أكثر لهدف الدراسة، كما إن الصيغة (ras.) للمرئية كان لها زيادة في ابعاد الوحدة الصورية (pixel) فضلا عن زيادة تفاصيل نمط شدة الوحدة الصورية في المستويات الرمادية الواطئة، وان قيمة العتبة (0,985) ضرورية جدا لنجاح عمل مرشح الانتروبي (Entropy). نتائج عمل الموديل الخطي ظهرت بشكل خارطة توزيع اعماق لبحيرة سد الموصل تبدا من ٠ وحتى 80 متر، حيث شغلت المناطق الضحلة والمتوسطة (60m>) العمق الجزء الجنوبي من البحيرة في حين شغلت المناطق العميقة (60m<) الجزء الوسطي والعلوي من البحيرة.