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The Satellite Images Matching and Mosaic Techniques

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Abstract

The Matching and Mosaic of the satellite imagery play an essential role in many remote sensing and image processing projects. These techniques must be required in a particular step in the project, such as remotely change detection applications and the study of large regions of interest. The matching and mosaic methods depend on many image parameters such as pixel values in the two or more images, projection system associated with the header files, and spatial resolutions, where many of these methods construct the matching and mosaic manually. In this research, georeference techniques were used to overcome the image matching task in semi automotive method. The decision about the quality of the technique can be considered if the error value is less than half a pixel. The projection-based method was used to ensure the mosaic process. The test images are satellite imagery with medium spatial resolutions; these images were processed to ensure the results. In matching techniques, the different sensor images (different in resolutions) were investigated using image resize and sampling. The results were obtained using many remote sensing packages and written programs in Matlab environmental.

Keywords: Images Matching, Images Mosaic

تقنيات مطابقة و ملاحكة الصور الفضائية

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الخلاصة

تلعب تقنيات مطابقة وموائمة الصور دورا مهما في الكثير من مشاريع الاستشعار عن بعد، والمعالجة الصورية للبيانات. أن هذه الطرق والتقنيات تفرض نفسها على المستخدم في مرحلة معينة من البحث أو المشروع، مثلا، عند إجراء التغاير الرقمي للصور الفضائية، وكذلك في الدراسات التي تشمل مناطق شاسعة. أن طرق مطابقة وموائمة الصور المعروفة غالبا ما تعتمد إما علي قيمة الوحدات الصورية، قيم المساقط المرافق لملف الصور، ودقة التمييز الحيزية، ويجري العمل بها يدويا.

في هذا البحث، تم استخدام ، التصحيح الهندسي كطرق مطابقة للصور الفضائية بطريقة شبه آلية. إن اتخاذ القرار على جودة الطريقة يتمثل بان تكون دقة التطابق اقل من نصف وحدة صورية. استخدمت طريقة المسقط الأساس لغرض إنجاز ملاحكة الصور. الصور الفضائية المستخدمة في البحث متوسطة

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دقة التمييز الحيزية لغرض إعطاء واقعية أكثر للنتائج. كذلك، تم استخدام صور من متحسسات مختلفة (اختلاف في دقة التمييز الحيزية) واستخدم لهذا الغرض طرق التحجيم وإعادة الترميم. تم الحصول على النتائج باستخدام برمجيات التحسس النائي ، وبرامج مكتوبة باستخدام بيئة الماتلاب.

1. Introduction

The satellite image matching process is essential to any remote sensing project that holds more than one image, especially in digital change detection and feature extraction. In all matching processes between two or more temporal imagery, the matched pixels from each image must hold the same physical positions, spatial and spectral resolutions, and sensors or not [**1**]. The digital matching process is a task that extracts images within the same size, features, and ground coordinates values. Users do the matching imagery manually in many remote sensing and image processing packages.

The second part of the project is to perform a mosaic between two interference satellite imagery. Image mosaics is essential in computer vision research and remotely satellite image analysis. The mosaic is applied to a sequence of images depending on the geometry of the pixels. The matching process differs from the mosaic in that, in the first process, the two images or more must be subset to the same size and features, whereas, in the second method, the images must be extracted in origin sizes but in new appearance concerning interfering region [**2**]. Also, the mosaic task was performed using the ground projection data recorded with each satellite image; these data include the spatial ground resolution, image size (row, column), and the upper left point coordinates values [**3**].

This research aims to build an auto-matching technique to match any two imagery with different sizes and positions but under the same ground coordinates system. The method depends on the projection system data associated with the satellite imagery.

2. Study Areas and Available Data

The rejoins of interest (ROI) consist of two areas, the first is in the amid of Iraq, including the capital, Baghdad city, while the second is in the north of Iraq, including Mosul city. The areas of interest represent full scenes of Landsat OLI and Sentinel B-2 for both cities, respectively. The first region is described as an urban area, i.e., buildings and streets with a small amount of vegetation cover. The average highest from the sea level is 36 m, where the Tigris River divides the city into two parts, and the geographic corners of the first area are;

NW corner, Lat. 34° 13′ 0.47″ N, Long. 42° 15′ 21.31″ E
NE corner, Lat. 34° 14′ 50.32″ N, Long. 44° 46′ 46.34″ E
SW corner, Lat. 32° 5′ 12.57″ N, Long. 42° 19′ 17.41″ E
SE corner, Lat. 32° 6′ 53.9″ N, Long. 44° 47′ 5.33″ E

The second region describes an urban area, the vegetable cover can be seen in the area, and the Tigris River divide the city into two parts; the average level above sea level is about 300m; Figure 1 represents the areas of study, and the geographic corners of the second area are;

NW corner, Lat. 37° 1′ 30.68″ N, Long. 42° 45′ 6.25″ E
NE corner, Lat. 37° 2′ 31.76″ N, Long. 43° 59′ 8.11″ E
SW corner, Lat. 36° 2′ 10.54″ N, Long. 42° 46′ 48.69″ E
SE corner, Lat. 32° 6′ 53.9″ N, Long. 43° 59′ 54.37″ E

A, The First Region of Interest

B, The Second Region of Interest

Figure 1: Study Areas, According to USGS Earth Explorers

The available data consist of four full scenes (RGB) satellite imagery, free of clouds, Table (1). Downloads were performed from Geological Survey (USGS) Earth Explorer (https://earthexplorer.usgs.gov).

Table 1: The description of available data

Sensor	Scene ID	Resolution (m)	Bands	Date	City
Landsat/OLI	LC08_L1TP_168037_20210716_20210721_02_T1	30	RGB	16-7-2021	Baghdad
Landsat/OLI	LC08_L1TP_168037_20210817_20210827_02_T1	30	RGB	17-8-2021	Baghdad
Sentinel-2B	L1C_T38SLF_A022469_20210625T075213	20	RGB	25-6-2021	Mosul
Sentinel-2B	L1C_T38SLF_A023184_20210814T075212	20	RGB	14-8-2021	Mosul

3. Images Matching Method

The matching techniques have become the most crucial process for many remote sensing and geospatial information projects due to the rapid increase in sensor types and corresponding data. Many well-known remote sensing and image processing packages do not include a geospatial method to match two or more imagery [**4**]. This paper aims to construct a program that matches two images or more in semi automotive way with high matching accuracy (less than half a pixel). Many remote sensing applications want an accuracy value of less than half-pixel to extract the results. To apply for the program, the input imagery was registered to a suitable ground projection, i.e., any similar features in the two imagery hold the same coordinates values. In the case of the above data, the images were registered to the UTM projection system, Datum WGS 1984, Zone 38 N, provided by the USGS. The projection data is available in the Meta file attached with each image [**5**].

The method used was a geo-based matching technique built on the Universal Transverse Mercator (UTM) projection system, the unit of this system is a meter [**6**]. The matching and mosaic process generally depends on matching the accurate physical position of the two or more images. The matching process was evaluated using a written program in Matlab environmental, which consisted of the following steps;

a. Prepare two pairs of images for each above sensor (two images in each pair) using the ENVI subset image facility; any two images in a pair were selected for arbitrary position to increase the method's reliability. They hold standard pixels that were extracted as matches area. The size of the first pair is (1972R*2001 C for the first image, 2401 R *2642 C for the second image), whereas the size of the second pair is (1000 R*1000 C for the two images).

b. Input each pair of images separately into the matching program, and the image extension is "TIF."

c. Feed the program with the upper left point coordinates values (UTM projection system) for the first pair (Baghdad, Landsat 8/OLI, E1=424425 m, N1=3727545 m), and (E2=427125 m, N2=3733545), for the second pair, (Mosul, Sentinel-2B, E1=324440 m, N1=4035280 m) and (E2=330020 m, N2=4027120 m). The program construct matrices of (E, N) values for each pixel, such as;

$$E(R,C) = E1 + C \quad (1)$$

$$N(R,C) = N1 - R \quad (2)$$

Where *R and C* are row and column, respectively,

d. The program seeks the match point, a point with two coordinates values in the (R, C) of two images but the same coordinate value in the UTM projection system. The following represent the match points data. The matching criteria are the equality for each Eastern and Northern value, then exit the for a loop.

- **Landsat 8 /OLI, Baghdad**
  #1, (1, 91), (R,C), (427125 E, 3727545 N) m
  #2, (201, 1), (R, C), 427125 E, 3727545 N) m
- **Sentinel-2B, Mosul**
  #1, (409, 280), (R,C), (330020 E, 4027120 N) m
  #2, (1, 1), (R, C), (330020E, 4027120 N) m

e. After finding the match point, the program examines each image's size and extracts only the matched pixels in the pair. In this case, the match point represents the upper left point for the two images in each pair, where the lower right point is the minimum row and column of any image in the pair. Figures 2 and 3 represent the first pair before and after the matching process. Figures 4 and 5 represent the second pair before and after.

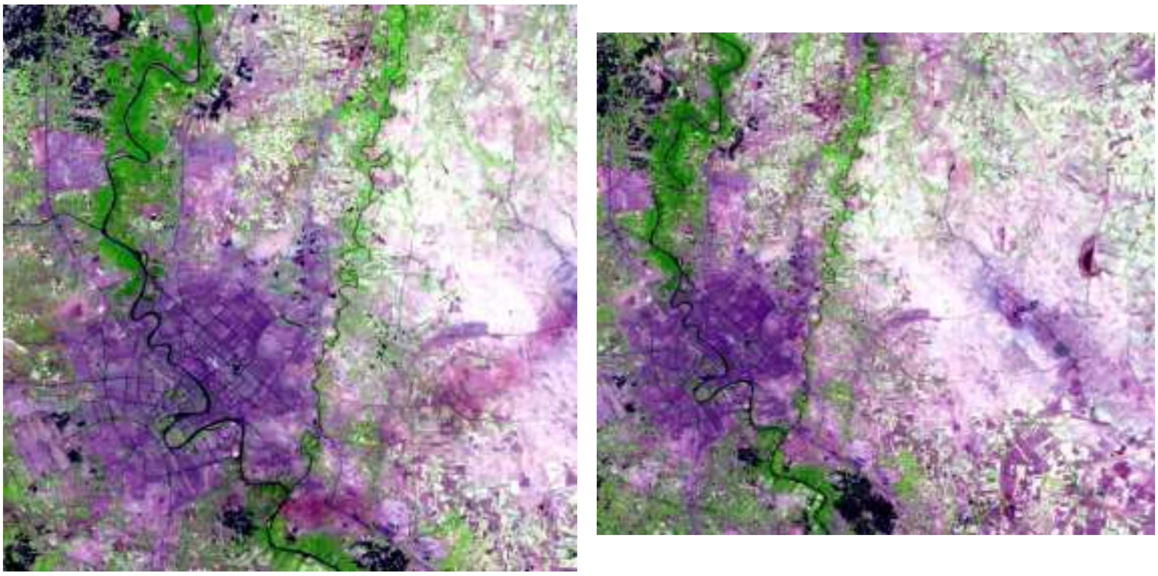

Figure 2: The first Pair, Landsat OLI / Baghdad

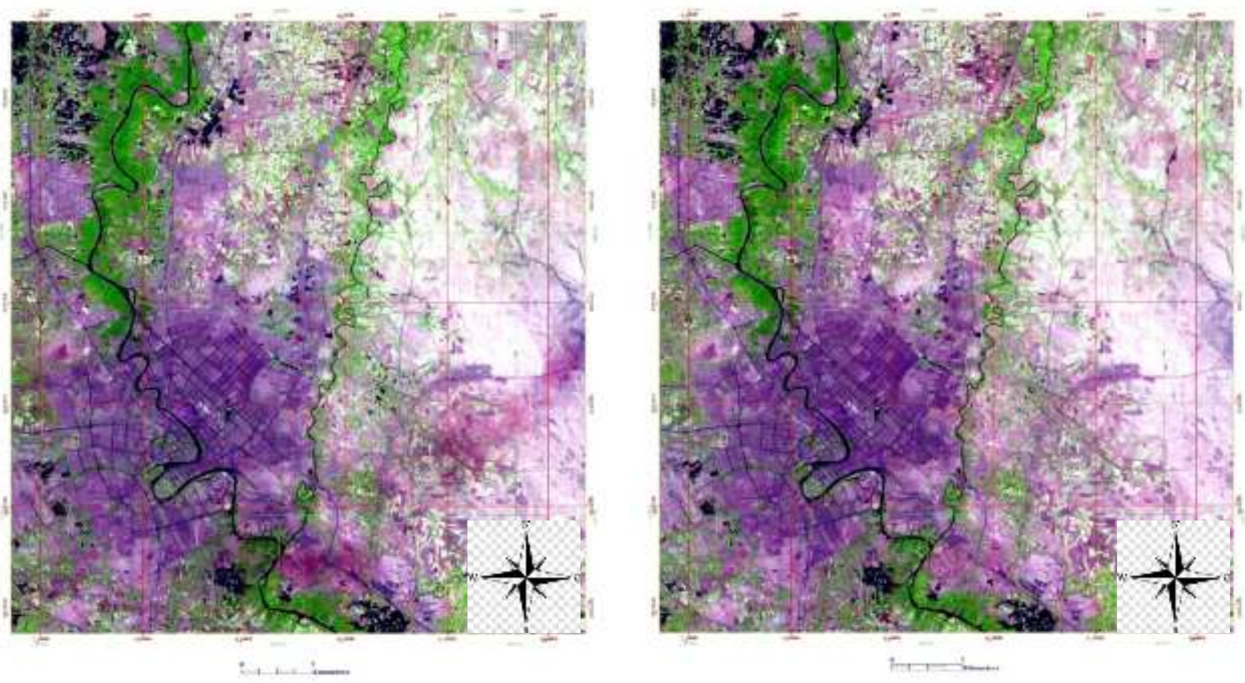

Figure 3: The Matched Images for first Pair, Landsat OLI / Baghdad, Size, 2001R*1882C

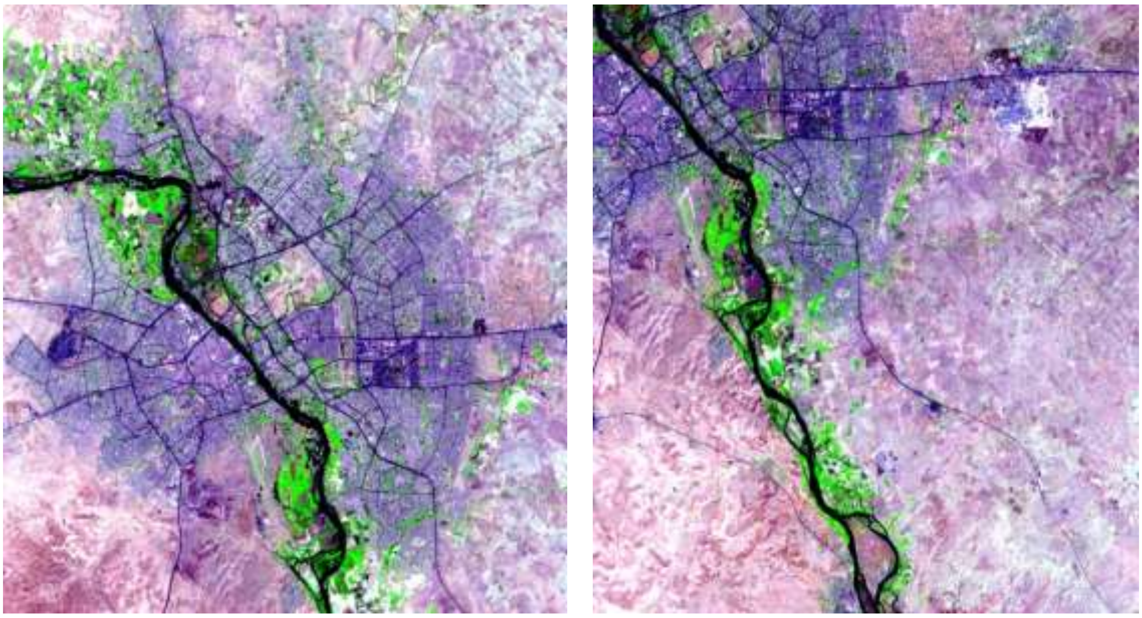

Figure 4: The second pair, Sentinel-2B, Mosul

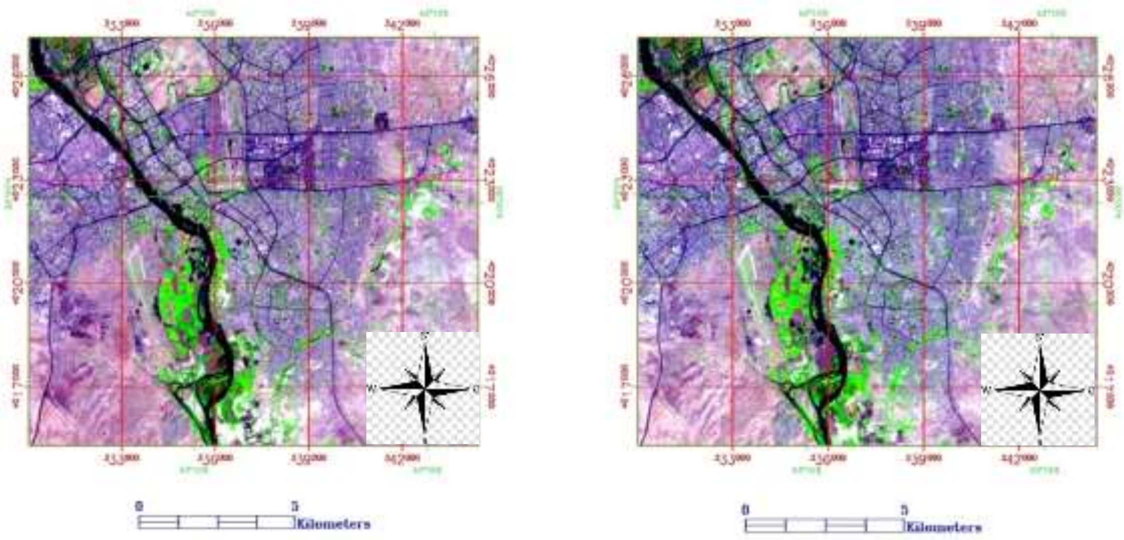

Figure 5: The Matched Images for second Pair, Sentinel-2B, Mosul, Size, 592R*721C
Geographical Coordinate System
UTM Coordinate System

4. Images Mosaic Method

The image mosaic is a modification process used to construct one image from two or more images. To extract the mosaic between images, the programmer needs to know the coordinates value of the tie point. The process is essential in video images and comprehensive remote sensing projects [**7**]. Many remote sensing and image processing packages hold two facilities for image mosaic. The first is a pixel-based method, whereas the second is a geo-based method. In the first approach, a user selects the tie point manually by seeking the similarity in ground features, while in the second method, the program seeks the tie point using the projection system coordinates values held by the images. This can be considered an automotive method to extract the mosaic. The famous projection system is UTM, which can extract the tie point; this projection deals with short areas in meter units, whereas the system deals with large areas in the geographic projection system [**8**].

The geo-base method was used to extract the mosaic areas for the same sensors used in the matching process, and the results were evaluated using the written program in Matlab, similar to the matching program. Apply the same stage from **a** to **d** used in paragraph 3; the tie point is the same as the matching point, but the next step will differ. At this stage, the program seeks to joint the two imagery from the tie point values in rows and columns in the image pair, and the joint criteria will extract the new mosaic image. In many mosaic tasks, users need to match the radiometric properties for the input imagery through histogram matching filters, and this was important to remove the straight line that appears in the region that mid between the imagery. The used pairs of the research were selected for a short duration, so the radiometric difference was minimal and needed no histogram matching filters. Figures 2 and 4 represent the two pairs before processing, whereas figures 6 and 7 represent the mosaic image results for the two pairs.

The program constructs a big zeros image that can hold the two images in sizes, starting from the tie point; the program can distinguish between the west and east image and join them as a line from the tie point. The mosaic images appear with black regions; in some boundaries, it subsetted to any size, but for show purpose, the region of the zero appeared. The tie line of the two imagery can be distinguished, but not in a firm tone.

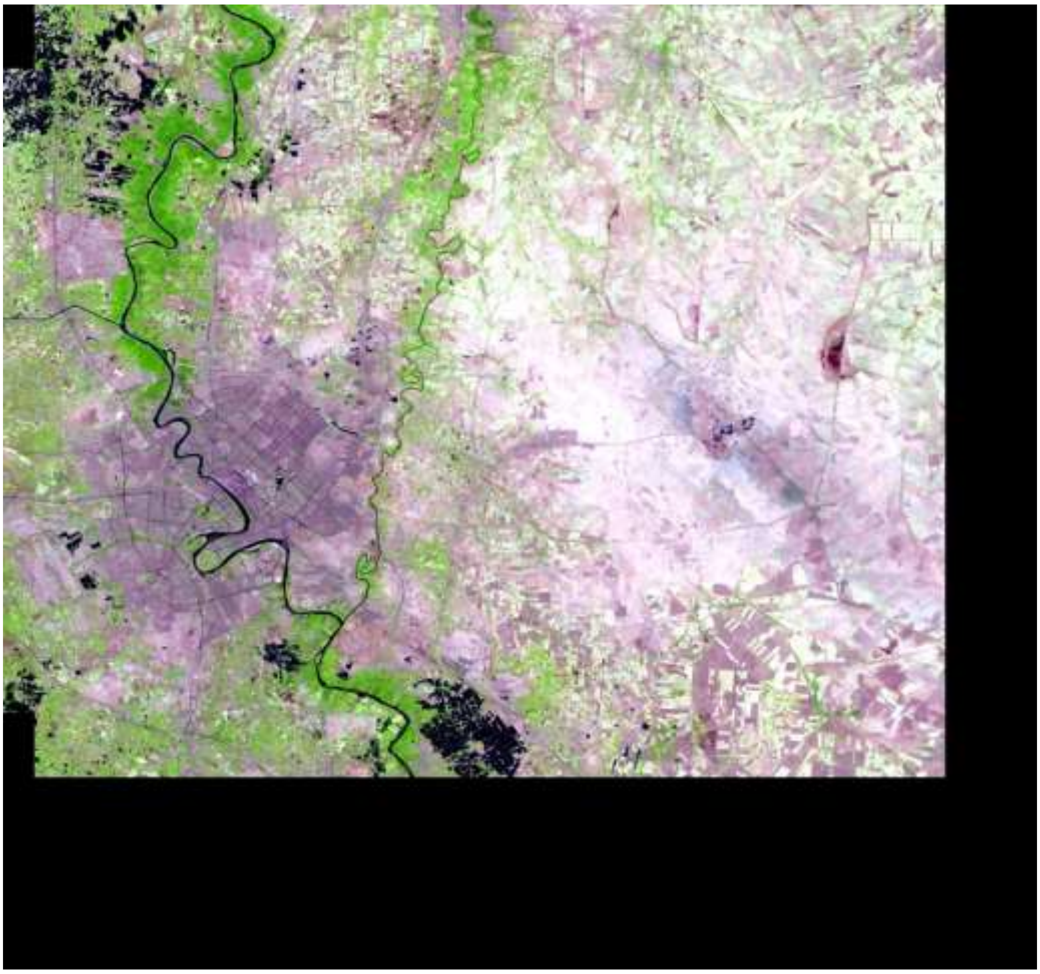

Figure 6: The Mosaic of The first Pair, Landsat / OLI, Baghdad

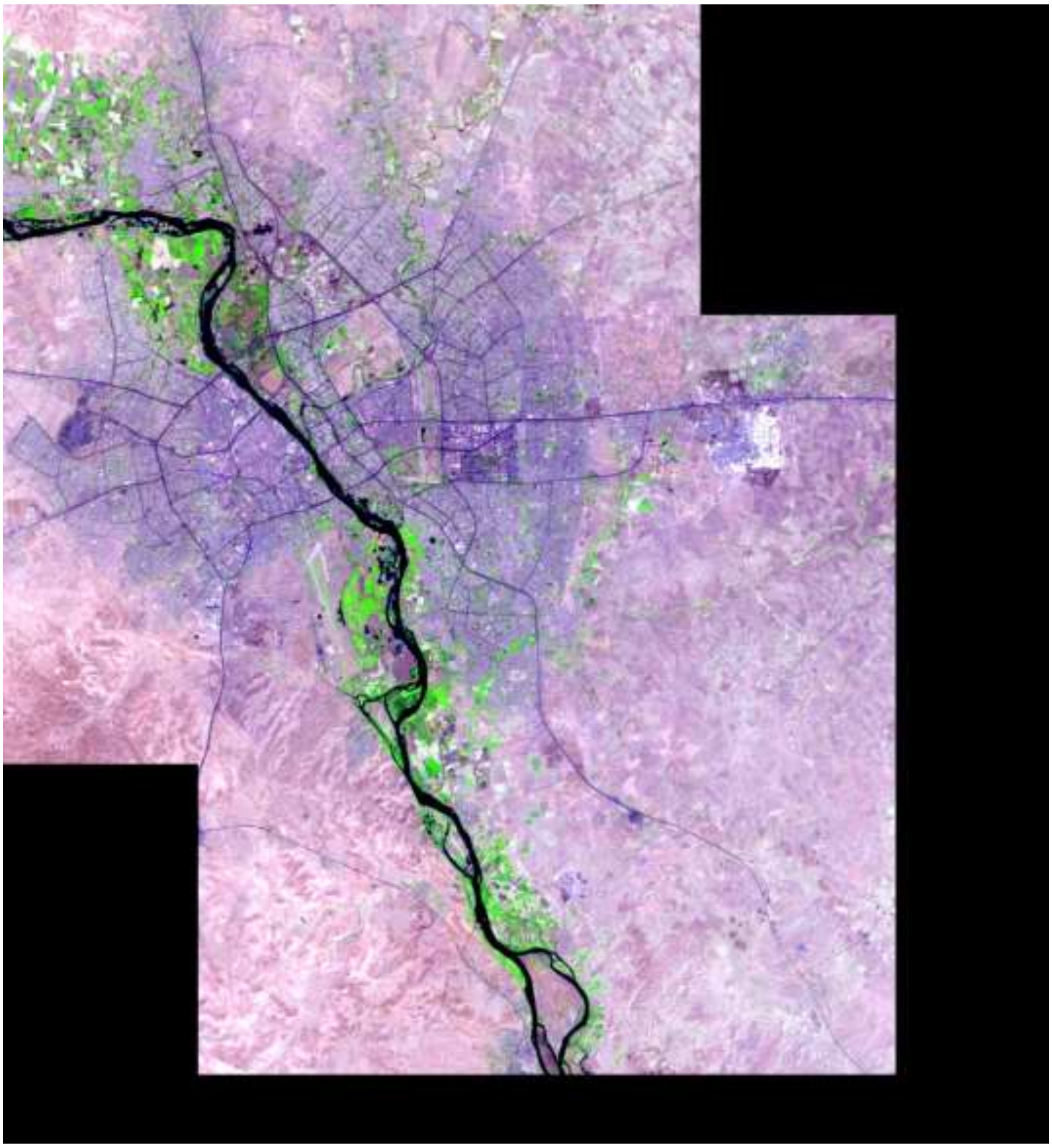

Figure 7: The Mosaic of The second Pair, Sentinel-2B, Mosul

5. Accuracy Evaluation

The accuracy of each method was evaluated by comparing the coordinates values for selected Ground Control Points (GCPs) with their coordinate value in the big origin scene; the difference between the two coordinates values is less than 15 for the first ROI and less than 10 for the second. The coordinates values were picked up from the ENVI cursor locating value facility, and the selected GCPs are streets intersecting as in Tables 2 and 3.

Table 2: The accuracy of the first ROI, matching method, Landsat /OLI, Baghdad

GCP#	**Calculated Coordinates**		**Origin Coordinates**		**Differences**		**RMSE m**
	E m	N m	E m	N m	E m	N m	
1	437895	3680490	437895	3680505	0	15	3.87
2	445935	3688485	445905	3688502	30	17	34.48
3	434895	3687855	434895	3687855	0	0	0
4	439015	3677565	439005	3677565	10	0	3.16

The Total RMSE=10.3775 m, less than 15 m.

Table 3: The accuracy of the second ROI, matching method, Sentinel-2B, Mosul

GCP#	Calculated Coordinates		Origin Coordinates		Differences		RMSE m
	E m	N m	E m	N m	E m	N m	
1	335030	4022880	335040	4022880	10	0	3.16
2	328780	4023700	328780	4023700	0	0	0
3	339305	4019885	339300	4019880	5	5	7.07
4	331344	4030860	331340	4030860	4	0	2

The Total RMSE=3.0575m, less than 10 m.
where;

$$RMSE = \sqrt{E^2 + N^2}\ \text{m} \quad (3)$$

$$TotalRMSE = \frac{1}{TotalGCPs} \sum_{i=1}^{TotalGCPs} RMSE\ \text{m} \quad (4)$$

6. Results and Discussion

From the above results and methods, two pairs of imagery were arbitrarily selected from the origin scenes in a matching method built on the geo-base projection.

• After finding the match points, the matching criteria can be concluded as follows;
For construction, the first match image
Rows =x1 to xm1;
Columns =y1 to ym1;
For construction, the second match image
Rows =x2 to Rows (image1) +x2-1;
Columns =y2 to Columns (image 1) +y2-1;
Where; (xm1, ym1), (xm2, ym2) are the rows and columns of images 1 and 2 before matching.
(x1, y1), (x2, y2) are the coordinates values in pixels for the match point for the first and second image, respectively.

• Note that this criterion is general to match any two imagery. Also, simple programming counters should be used.

• After finding the tie points, the mosaic criteria can be concluded as follows;
Construct the first mosaic area;
Rows =x2 to xm1+x2-1;
Columns =1 to y1;
Construct the second mosaic area;
Rows =x1+1 to xm2+ x1;

Columns =y1+1 to ym2+y1;

- The matching and mosaics resultant images hold a suitable coordinates value from the total mean square errors compared with the original scene.
- The above criteria were applied to the two pairs and represent the optimum subset values to extract the results.
- The programs save the results as "TIF" extension imagery.
- The limitation of this work is missing the correct ground coordinates values for input images.

7. Conclusions

- The paper aims to construct semi-automotive methods for matching and extracting mosaic between any two imagery.
- For this purpose, two intersection regions were selected, the first in Baghdad, with Landsat /OLI sensor, and the second in Mosul with Sentinel-2Bsensor. The first sensor is of 30 m resolution, whereas the second sensor is 20 m.
- The work methods were built on the UTM projection system to find each pair's match and tie points.
- After finding the match and tie point, a general subset of criteria was applied to extract the results.
- The accuracy values satisfy the general condition of work with the satellite imager that the error value does not exceed half a pixel.

References

[1] W. Drioua and N. Benamrane, "Satellite Image Matching using Kalman Filter and a cross correlation technique Analyse et traitements d'images médicales View project Classification and segmentation of tumor cerebral View project," *Artic. Int. J. Sci. Eng. Res.*, vol. 6, no. 2, pp. 687–691, 2015.

[2] P. Jain and V. Shandliya, "A Review Paper on Various Approaches for Image Mosaicing," *Int. J. Comput. Eng. Res.*, vol. 3, no. 4, pp. 106–109, 2013.

[3] I. Muhsin and A. Mohammed, "Detecting and Monitoring the Vegetal Cover of Karbala Province (Iraq) Using Change Detection Methods," *Iraqi Journal of Science*, vol. 58, no.3A, pp. 1345-1354, 2017.

[4] Y. Ye, L. Bruzzone, J. Shan, F. Bovolo, and Q. Zhu, "Fast and Robust Matching for Multimodal Remote Sensing Image Registration," *IEEE Trans. Geosci. Remote Sens.*, vol. 57, no. 11, pp. 9059–9070, 2019.

[5] C.-R. Huang, H.-P. Lee, and C.-S. Chen, "Shot Change Detection via Local Keypoint Matching," *IEEE Trans. Multimed.*, vol. 10, no. 6, pp. 1097–1108, 2008.

[6] M. Zolfaghari, E. Amini, and H. Mozaffari "Analysis of Universal Transverse Mercator projection and Coordinate System."Thesis, (2012).

[7] L. Shuhan, L. Hongzhou1, W. Xia1, G.Li1, and W.Rui., "Study on Mosaic and Uniform Color Method of Satellite Image Fusion in Large Srea," *ISPAr*, vol. 42.3, no. 3, pp. 1099–1102, Apr. 2018.

[8] A. Stumpf, J. Malet, and C. Delacourt, "Correlation of satellite image time-series for the detection and monitoring of slow-moving landslides," *Remote Sens. Environ.*, vol. 189, pp. 40–55, 2017.