Semi-automated delineation of target from high resolution satellite imagery

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Abstract: For large scale mapping & manual digitization process is most cumbersome and time consuming its constraint necessitates automation. Delineation of target of interest has been carried out using Cartosat -1 satellite data along with DEM derived from IRS P5 stereo pair. High resolution satellite data does not follow the normality of class's assumption and therefore edge detection followed by segmentation is viable solution. Morphological operator in ArcGIS is used for shape preserving edge detection. Edge thus generated forms the boundary of segment. Object oriented classification has its own advantages but jagged outlines are generated. Binary image does not require line thinning. Auto vectorisation attempted has some in-built processing 'cleaning' of images. Post processing usually requires editing still not comparable with human interpreter. Improvement consists of generalisation in GIS environment with no topological problem. The result thus obtained serves both qualitative and quantitative detection of feature of interest.

Introduction

For large scale mapping & manual digitization process is most cumbersome and time consuming this constraint necessitates automation. Manual drawing of features has been facilitated by extensions provided with ArcGIS, which have tools which enhances its versatility at the same time creating organised database. Extractions of linear feature using semi-automated methods have been proposed (Gruen *et.al.*, 1997). Active control models (Snakes) work on the concept of LSB (least square β spline). This has both advantages of geometric as well as photometric constraints. In object based method after extraction of the object (boundary delineation) than comparing for change assessment through LIST - Landscape interpretation tool (Lang *et. al.*, 2007). Automation of discrepancy detection was attempted using technique for map to image by iterative trimming on segmented image (Radoux *et. al.*, 2010*).* Medial line tool is used in current method. Size Constraint Region Merging (SCRM) uses gradient image of DN values and parameters for delineation of polygon are its size vertices distance (Castilla *et. al.*, *2008*), useful in segmentation. Largely it is applying image interpretation on pixel level and then applying object feature constraints.

The Cartosat-1 satellite has a number of advantages that it provides high resolution near-instantaneous stereo data with a spatial resolution of 2.5m and 10-bit quantization. The Cartosat-1 carries two Panchromatic cameras, which generate stereoscopic image of the area along the track. Spatial resolution of 2.5 m, to acquire two images simultaneously, one forward looking (fore) at +26 degrees and one aft of the satellite at -5 degrees for near instantaneous stereo data with repetivity of 126 days. Currently CartoDEM in part is used in 3D mode of "Bhuvan" geo-portal of ISRO showcasing Indian Earth Observation (EO) capabilities.

Study area

The study area is covering geographical area of 2752.67 Sq km. A buffer around the tentative canal feature, drawn on small scale map. It is located in North Western part of Jodhpur city, India. The Rajeev Gandhi lift canal from main Indira Gandhi Nahar Pariyojna (IGNP) stage-I was constructed to fulfil the drinking water requirement of the Jodhpur city & three towns Bilara, Samdari & Phalodi along with 729 villages of Jodhpur, Jaisalmer and Barmer districts of Rajasthan. Since city is located at higher elevation lift canal was constructed with 8 pumping station. The off take point is Madasar village at RD 1109 and it joins Kaylana lake North-West of city, which is used as storage reservior. The canal is around 206 km and at some places supply is through MS pipes. The study area lies between 26°14'53.69" to 27°14'12.86" E latitude 72°14'40.99" to 72°14'40.99" N longitude. Running length of canal covered is approx. 127 km in study area. The terrain is varied from dunes to inter-dunal plain and stony lying North peak 345 meters above MSL and lowest in the area of 140 meters elevation.

Objective

For extraction of canal from high resolution digital satellite data and to achieve the object delineation (canal), following objectives were kept -

- Registration of other GIS layer with orth-orectified satellite data
- DEM, orthoimage and gradient map generation
- To apply diffusion - gamma correction) and contrast enhancement
- Smoothening and edge detection (morphological operation)
- Segmentation to extract lines (binary) & imposing geometrical constraints
- Line thinning for ribbons within canal buffer, topology rules testing and manual correction.

Methodology

Orthorectification of image was carried using DGPS points & DEM for mapping accuracy of small feature. Diffuse with suitable value of gamma correction is used for clearing the halo along a linear data generated due to adjacency effect of vegetation pixels besides deleting the artefacts. In the context of canal unlike road the general gradient is followed, which is surrogated by the Digital Elevation Model (DEM) generated by processing the Cartosat -1A stereo pair using RPC. Further, editing carried out to improve DEM by eliminating trees and adding break-lines. Ortho-image is generated by removing terrain related distortion for delineation of object.

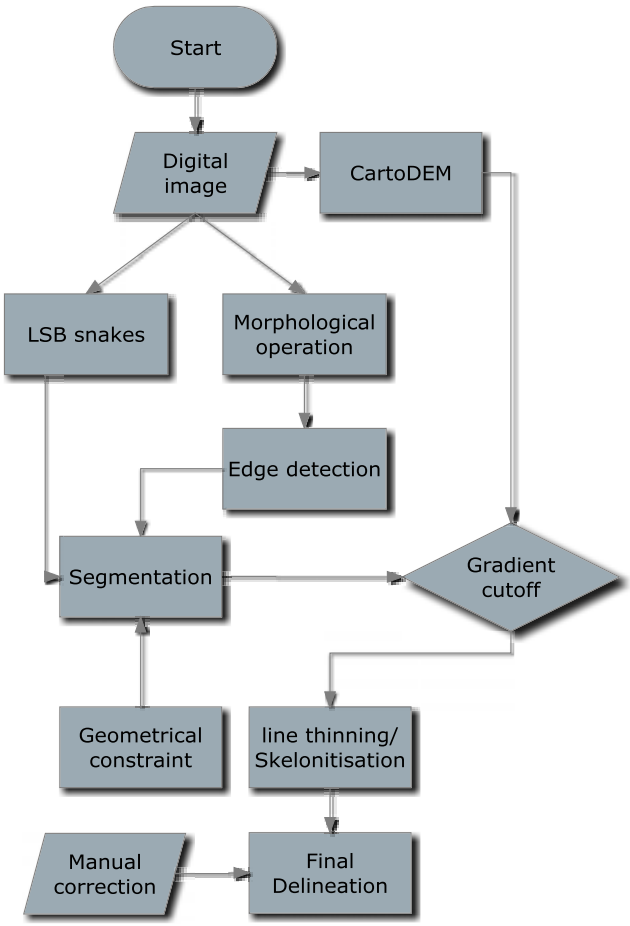
Morphological operator in ArcGIS is used for shape preserving edge detection. Cleaning of image becomes necessity to remove noise. As features tend to blur with background, to highlight contrast enhancement was carried out. Edge thus generated forms the boundary of segment.

Generic canal model used for canal extraction, while the road pixel is assumed to be lighter than its neighbour on both side canal, which is darker (very low luminance) compared to surroundings due to absorption of energy by water in all bands. Surely, there are no obstacles (vehicles) unlike road. Contrary to irrigation canal it does not have irrigated agriculture but afforestation along canal is distinct feature. The canal will not have branches joining at acute angle with reference to direction

of flow. However, depending upon terrain the similarity in terms of roads joining at right angle does exist.

Segmentation is a process of separating different homogenous regions by the spectral properties based upon multiple region growing processes. Regions such produced have both spectral as well as spatial entity. It is preferred technique over pixel based classifier particularly for high resolution panchromatic data.

Delineation of linear feature is controlled using straightness & smoothness of curve of canal feature. Snapping to known DGPS points and pump house representing junction of feature is used for accuracy improvement. Topology forming rules that controls relation is created and later checked by applying test.



The methodology adopted for this study is depicted in flowchart and described below -

1. Satellite data input starts with procurement of suitable high resolution data pertaining to Resourcesat-1 (IRS-P6) LISS IV and corresponding stereo pair PAN data CARTOSAT-1A with RPC followed by ortho-rectification. Ancillary spatial information was registered with this image.

2. CartoDEM generation and refinement of DEM carried out by further editing (removing erroneous points and adding break-lines).

3. Morphological operators were used for shape preserving smoothening filling the holes & deleting small artefacts followed by contrast enhancement for edge detection.

4. Instead of classification existing robust technique LSB snakes has been utilised for generating building block, further operations were performed on this output. All DGPS/ pumping sites, cross road, bridges, and routes along & near canal have been digitized.

5. Image segmentation carried out to delineate linear features. Geometrical constraints in terms of linearity & smoothness of curve enforced on segmented image. Gradient images derived from DEM were used for gradient cut-off. Inverse model of drainage *i.e.* local maxima is used with thresh holding and line thinning is done for centre line delineation.

6. Buffer around canal area was corrected manually and finalised after topological rule tested for pseudopods, dangling arcs, common vertices of cross road/ bridges.

Results & Discussion

At the pre-processing stage diffusion to delete small spots and fill holes and contrast enhancement have been done to extract and correct data to extract lines from the background. High resolution satellite data does not follow the normality of class's assumption and therefore edge detection followed by segmentation is viable solution. Morphological operators in ArcGIS were used for shape preserving edge detection. Edge thus generate forms the boundary of segment. Object oriented classification has its own advantages but jagged outlines are generated. Binary image does not require line thinning but centre line of canal delineated using DEM needs skeletisation.

Conclusion

It is a collage wherein set of tools are utilised to fulfil the objective of delineation of feature using high resolution satellite images in GIS environment. Besides facilitating geospatial data integration derived from satellite data, the GIS has substantiated by DEM as well as collateral information. The ease and a lesser amount of time taken in delineation of feature of interest *i.e.* mapping centre line of canal using the GIS also later help in management activity.

Acknowledgement

Author is thankful to Dr V.K.Dhadhwal, Director, NRSC, Hyderabad & Dr Y. V. N. Krishanamurthy Dy. Director (RSA), NRSC, Hyderabad for their encouragement.

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