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Updation of Topographic Features Using Landsat-7 Images

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Abstract

Updations of topographic features in a map were mainly based on Aerial photographs and ground surveys. Since that time, huge population growth and urban development have resulted in continuously expanding infrastructure and urban settlements. In addition, environmental factors including desertification, deforestation, flooding, and erosion have dramatically changed the land use and topography of some parts of the world. Due to these huge changes Updation of these data becomes very difficult on a continuing basis. In this research it is shown that just after the lunch of LANDSAT-7 Satellite the potential source for updating topographic sheets at 1:50000 becomes a reality for all the geographers and its magnitude in terms of different entities presented on the topographical sheets are validated and cross verified the same features through LANDSAT-7 images to attain the producer accuracy.

Introduction

The most important base of maps in geographical study relies upon topographical maps because of their accuracy level. But periodically topographical maps are not updated. So to fill this gap this study is conducted by using images of LANDSAT-7 satellite at a scale of 1:50000, (Boutin D., Massé F., 2001). And these images are further computed and correlated on the basis of orthophotos. Many features are identified on land cover by fixing a set of parameters and some criteria's to extract the features and further cross checking of their accuracy level (Bélanger D., Benoit A., 2002). For referencing and evaluation purpose vector database is considered to interpret the object's quality. A different kind of data set is used to conduct this study such as LANDSAT-7 images with 15 m resolution as a panchromatic and 30 m as a multispectral; orthoimages and vector database (CTIS, 2001).

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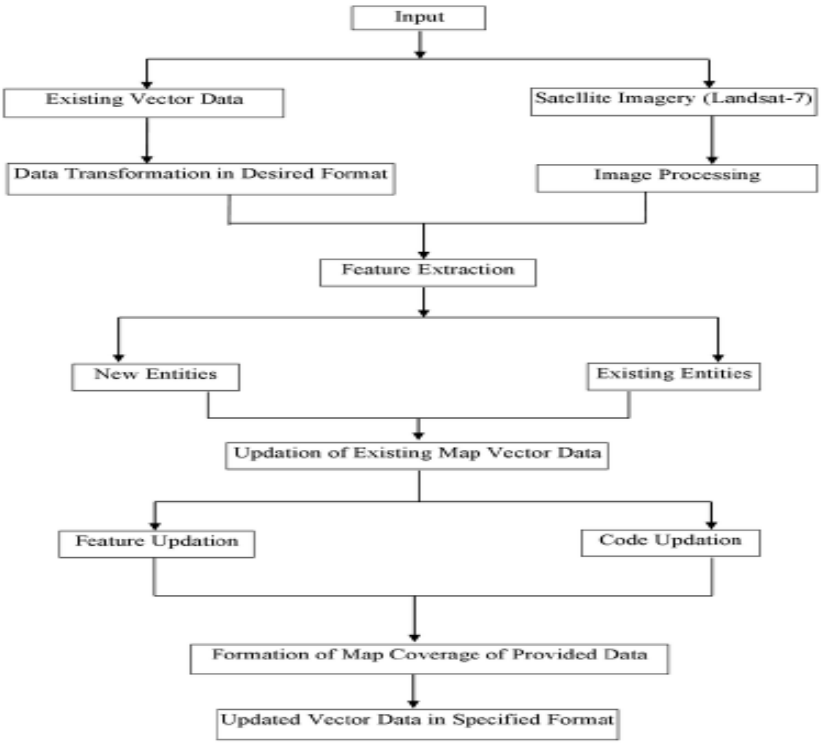
Methodology

The objective of this research is to enhance the planimetric accuracy of existing data. As well as to update a topographic data for the formation of an up to date mapping coverage. Furthermore, to restructure the data in the format that complies with international standards in a new database means geospatial database (Lillesand, T. M. and Kiefer, R. W., 1994). The following data is used**:** Vector database, Data statistics, Metadata file, Landsat Orthoimage, Table of Identifiers.

Research Methodology Steps



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Study Area- Image Processing and Data UpdationVector topographic database were developed from population maps prepared decades ago and many attempts for update projects have been made in recent years, but nothing really succeeded. The huge population growth, coupled with the variety of natural and environmental factors have greatly affected the topography of provided area. Population growth has caused great expansion in urban settlements, as well as the development of new settlements that did not exist by the time Topographic maps were developed. Infrastructure has greatly expanded, and so many roads and major pipelines were constructed since that time. Natural and environmental effects including desertification and deforestation have greatly affected the land use classification. Erosion and sedimentation has immensely changed the topography, and Updating process took place using Landsat-7 satellite imagery. However, as the need to update topographic data continues to grow, the costs involved (aerial photographs and high-resolution satellite imagery) were simply prohibitive. The launched LANDSAT-7 satellite opened the door to new possibilities for data providers and users. As such, projects for generating ortho-images to be used in the updating process would become possible in the future when the satellite parameters become available and the ortho-rectification models are developed for the LANDSAT-7 (Arvidson, T., Gasch, J., Goward, S.N., 2001).

Major consideration in the methodology include are:

1. LANDSAT-7 Orthoimage and Planimetric enhancement.
2. Vector database.
3. Selection of the updating method.

Satellite Data- Landsat-7 Ortho images

The orthoimage was produced from Landsat-7 images and includes spectral bands 1 to 8; a single Landsat-7 orthoimage normally covers the entire data set to be acquired. All the bands are clipped on the basis of the size of each data set to be produced and delivered along with the complete orthoimage that is in TIFF (.tif) format, as per the requirement. Multispectral bands (1 to 5 and 7) have a resolution of 30 m. Thermal band (band 6) has a 60-m resolution. Panchromatic band (band 8) has a 15-m resolution. Consequently the quality of these images is not fine because of the low resolution of LANDSAT-7 which adds to the deterioration of the quality of images. (Arvidson, T., Goward, S., Gasch, J., Williams, D., 2006). It is believed that by the time image enhancement process has finished, the image quality has highly improved (The spatial resolution of Landsat-7 is different for different bands so to differentiate between entities we use different techniques like PCT (Principle Component Transformation), NDVI (Normalized Difference Vegetation Index), SAVI (Soil Adjusted Vegetation Index), NDWI (Normalized Difference Water Index). With the help of these techniques we could easily identify area features like water body, vegetation, swampy/marshy etc.

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Fig-1

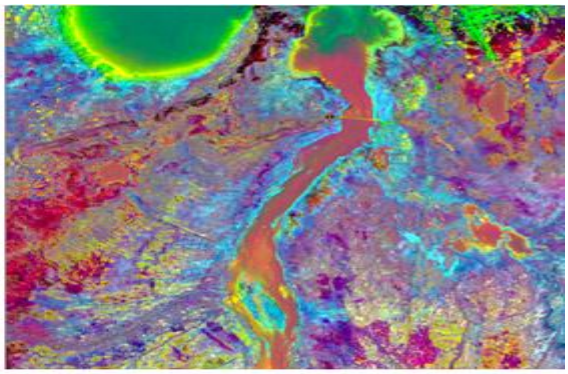

Fig-2

Fig-1 showing original image (MERGED) taken from LANDSAT-7 satellite
Fig-2 Showing PCT Output Image using image enhancement technique

Vector Data Base

The vector database data were captured from aerial photographs and ground surveys. Vector database cartography was therefore based on more detailed information than the Landsat-7 orthoimages used today for updating. The main sources of change are human and faunal activity, targeted natural events and natural disasters (examples: dam construction, logging, drainage, forest fires, and landslides). The provided vector database is in ascii format then convert it into drawing via text format after that overlay this drawing on a Landsat-7 orthoimage. Observe the changes between the provided (old) data and the vector database (Arvidson, T., Goward, S., Gasch, J., Williams, D., 2006)

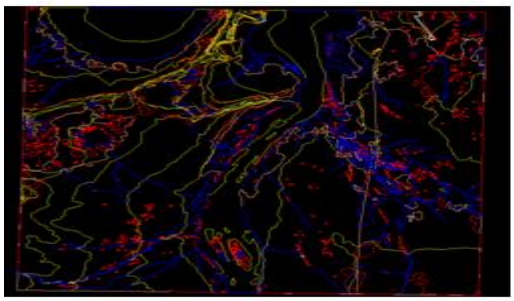

Fig -3

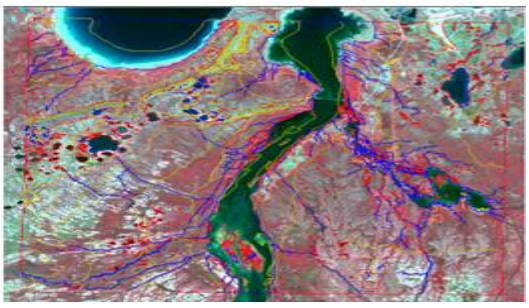

Fig-4

Fig -3 Showing vector database (old) themes in .dwg format

Fig- 4 Showing old vector database overlaid on Landsat-7 orthoimage.

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Evidence of Change

Evidence of change is necessary before an updation is done these consideration explains this. It means that the terrain can be unequivocally understood from the orthoimage and that interpretation demonstrates that the terrain has changed in permanent manner with respect to the vector database. If it is not the output of a seasonal phenomenon (flooding etc.) we can say it is a permanent change. In this context special focus must be given to the orthoimage date before a change is captured. Evidence of change can consist in the following: 1. a modification of existing features 2. A new capture 3. A confirmation and deletion. The vector data contain many topographic features but as per the requirement these fourteen themes have to be considered.

Vector Database Themes

Themes are groupings of vector database entities. The vector database has 14 entities, such as roads, contours and water bodies. The themes in the vector database are:

DA - Designated areas (camp, cemetery, zoo…)
RD - Roads (limited-use road, ford…)
MF - Manmade features (built-up area, building, wind-operated device…)
RL - Relief and landform (cave entrance, esker…)
GN - General (discontinuity point)
HD - Hydrography (permanent snow and ice, waterbody…)
HP - Hypsography (contour, elevation point)
TP - Toponymy (toponym)
PN - Power network (valve, pipeline, transmission line…)
RL - Rail network (railway)
RO -Road network (road, highway exit, ferry route)
WS - Water saturated soils (wetland, tundra pond…)

Selection of an Update Method

The main reason is that given topographic maps of 1:50,000 were based on very high-resolution aerial photographs. For this visual interpretation or visual inspection method is best suited. Visual inspection approach can be deemed more appropriate in this case.

In this research, two types of updation is done which is mentioned below -

3.1 Feature Updation

First comparison between the provided vector database and the landsat data is done. On this basis identification of existing and non-existing features was possible. Updation of the fourteen themes as mentioned in topographic database, have started as per their rules and regulations.

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Orthoimage Interpretation	Topographic Features to Updated	Various Situation	Capturing Method to be Used
It allows unclear interpretation of the terrain.	The orthoimage shows a new feature with a valid entity type	**NEW CAPTURE**	Geometry captured from the orthoimage.
	The orthoimage shows a change of geometry.	**GEOMETRY MODIFICATION #**	
	The orthoimage shows a change of code.	**CODE MODIFICATION ##**	Geometry copied from the vector database.
	The orthoimage shows a no change of geometry.	**CONFIRMATION**	
	The orthoimage shows that vector database is no longer exists.	**DELETION ###**	
It does not allow unclear interpretation of the terrain.	The orthoimage cannot be used to update the vector data base feature.	**TRANSFER**	

Table 1: Table showing feature updation

In the case of the modification of a feature's geometry, modify only those segments that have changed.

In the case of the modification of a feature's code, only modify the code with a code from the same theme.

In the case of the deletion of an entity, it requires that the entity be preserved and returned as captured in the topographic database with the exception of the ID_OCCURRENCE attribute, which must be modified to indicate that the entity has been deleted. Change tolerances apply to those situations where the geometry of existing features is modified. Change tolerances are expressed as "Minimum Range of Change" and "Lateral Tolerance of Change". A visible entity in the orthoimage that exists in the topographic database must be modified when both of the following conditions are met: The area of the change exceeds the "Minimum Range of Change". The width of the change generally exceeds the "Lateral Tolerance of Change".

Examples of Confirmation

The vector database indicates the presence of a lake, and the orthoimage shows an area whose perimeter corresponds to that of the entity in the vector database. Moreover, the orthoimage shows that the area is still comprised of water. The

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orthoimage therefore confirms the geometry and description of the vector database feature. Copy the feature from the vector database. The vector database indicates the presence of a domestic wastes site and the orthoimage shows an area whose limits correspond to those of the feature in the vector database. On the other hand, the land use at this location cannot be identified on the orthoimage. The orthoimage therefore only confirms the geometry of the vector database feature. Copy the feature from the vector database.

Example of Geometry Modification

The vector database indicates the presence of an urban built-up area. The orthoimage shows beyond any doubt that the area has expanded, and the expansion complies with change tolerances. Moreover, the orthoimage shows that it is an urban built-up area. Since there is evidence of change, modify the perimeter of the feature based on the orthoimage (Civco, D.L., 1989)

Example of Code Modification

The vector database indicates the presence of a permanent lake. The orthoimage shows beyond any doubt that the lake is totally drained (no water or moisture), and the size of the area complies with change tolerances. Since there is evidence of change, modify the code of the feature to that of an intermittent lake and keep its vector database-based geometry.

SITUATIONS	VECTOR DATA BASE	LANDSAT-7 DATA BASE	DESCRIPTION
DELETION	 ID_OCCURRENCE= X	 ID_OCCURRENCE= -X	The identifier of this identity should be negetive
CONFIRMATION, TRANSFER AND CHANGE OF CODE	 ID_OCCURRENCE= X	 ID_OCCURRENCE= X	Identifier should be same for entity
NEW CAPTURE		 ID_OCCURRENCE= X	The occurance of the new entity has a "0" identifier.
CHANGE OF SIZE OR SHAPE	 ID_OCCURRENCE= X	 ID_OCCURRENCE= Y	Identifier should be same for entity
CHAINING	 ID_OCCURRENCE= X ID_OCCURRENCE= Y	ID_OCCURRENCE= X/Y	A chained occurance maintain all the identifier of its entity occurance followed by "/
SEGMENTATION	ID_OCCURRENCE= X	 ID_OCCURRENCE= X ID_OCCURRENCE= Y	Each segment of a subdivided entity occurrence has the identifier of the original occurrence.
CHANGE IN GEOMETRY	 ID_OCCURRENCE= X	 ID_OCCURRENCE= -X ID_OCCURRENCE= Y	A change in the geometry representation(linear to point, area to linear) should be treated as deleation of original entity followed by a new capture.

Table-2 summarize the actions that must be taken for the identifiers, depending on the situations.

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Example of New Capture

There is no feature in the vector database. The orthoimage indicates beyond any doubt that a new lake exists and that this phenomenon complies with LANDSAT 7 minimum sizes. Capture the new feature based on the ortho image.

Example of Transfer

The vector database indicates the presence of a wetland, but nothing on the orthoimage confirms it. On the other hand, the orthoimage shows nothing that would contradict the presence of a wetland at that location**.** Since there is no reason to confirm or delete the feature, transfer it from the vector database.

Example of Deletion

The vector database indicates the presence of a wetland while the orthoimage shows an urban development. This information is contradictory and indicates that the wetland was probably drained. The occurrence is therefore deleted. Copy the feature from the vector database and modify the ID_OCCURRENCE attribute to indicate that the feature has been deleted.

Figures showing updation of topographic features theme by theme:
Manmade features (MM) the Figures below is an example of man made feature. Fig-5.1 shows a runway in an old vector database which is to be updated and Fig-5.2 shown an updated runway extracted from Landsat-7.

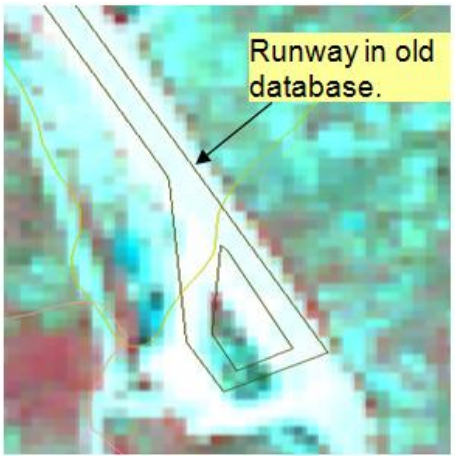

Fig-5.1

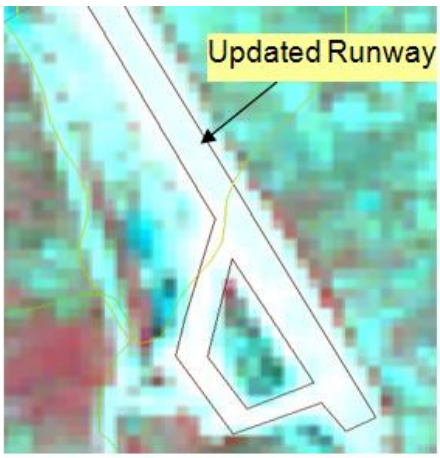

Fig-5.2

Hydrography (HG) in Fig-6.1 there are some original water bodies in which some kind of changes have observed i.e. some have expanded and few have shrinked, which needs to be updated and Fig-6.2 shows the updated water bodies extracted from LANDSAT-7.

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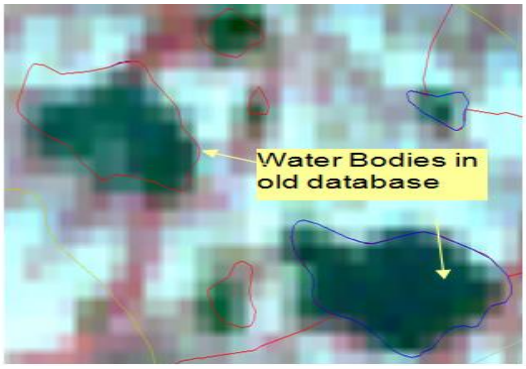

Fig- 6.1

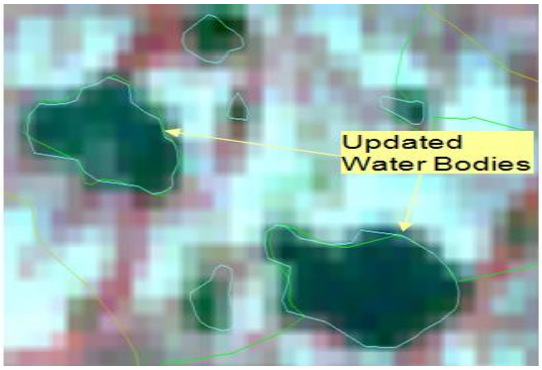

Fig- 6.2

Case -1: During updation of hydrographic feature i.e water bodies mainly two kind of water bodies were observed permanent waterbody and intermittent waterbody (they are formed due to change in the climatic condition i.e rainfall, flood etc...). Sometimes it is difficult to interpret whether there is permanent waterbody or intermittent waterbody. The Fig-C shows both types of water bodies (Gao, Y., Zhang, W., 2009).

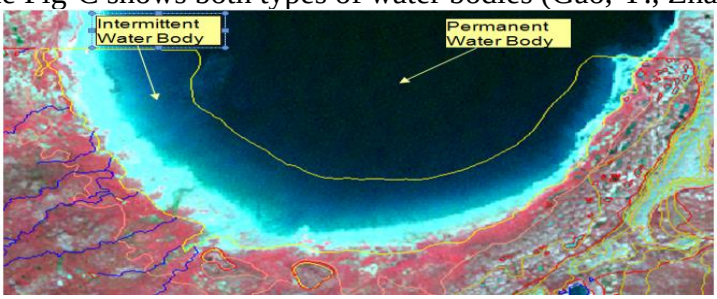

Fig - 7

Intermittent Water

Areas of intermittent water have different characteristics depending on the type (lake, ocean or river). Each type has its own water dynamic. For this reason, it is almost impossible to create general update rules that can be applied to all. Therefore, the interpretation and updates will be different for each water type. The following sections contain specific instructions by water type. Special care must be taken where two types meet. For example, where a river meets a lake or an ocean, a coherent continuity of the water features must be assured.

- Intermittent Water, River

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This type of water feature is characterized by significant erosion, transport and deposition of materials. Many changes must be anticipated when comparing the vector database data capture dates and the dates of the Landsat7 images. Areas of intermittent waters are defined as zones where the action of water-level fluctuation uncovers the ground on a regular basis. On the Landsat7 image, these are non-vegetated areas, whether they are wet or not. vector database Sand: Other and Sand: Underwater entities found inside or outside and adjacent to a Water: Permanent, River entity will be coded intermittent if the image and the context show that the water has an influence on the bare ground identified (Gao, Y., Zhang, W., 2009) (see Figure 8.1 and Figure 8.2)

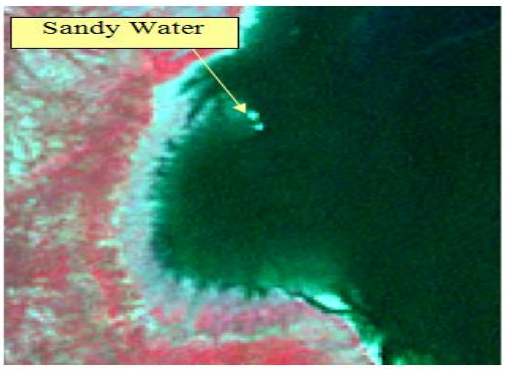

Fig-8.1

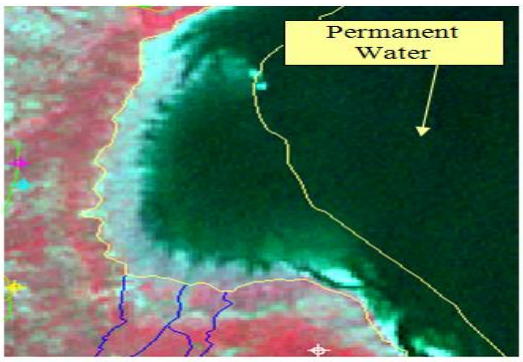

Fig-8.2

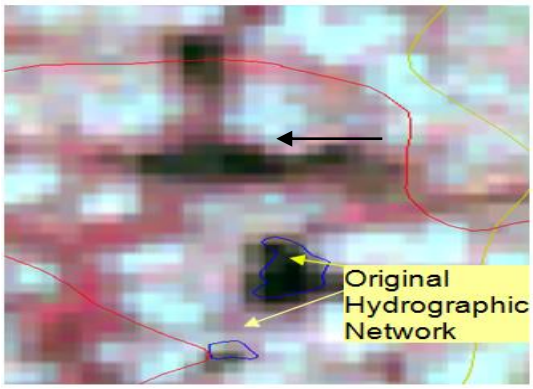

Fig-9.1

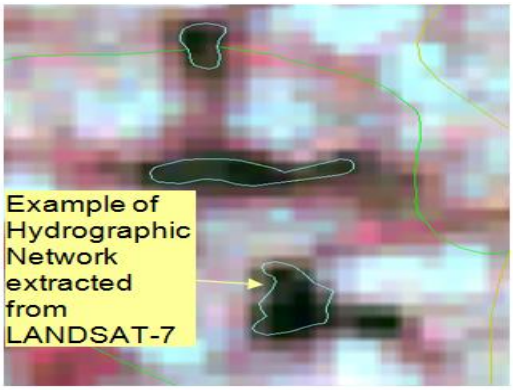

Fig-9.2

Fig-9.1 shows original water body and Fig-9.2 shows the captured water that is extracted the Landsat-7.

Water Saturated Soil (WS) Fig-10.1 shows presence of uncaptured saturated soil in an old vector database and Fig-10.2 shows captured saturated soil extracted from LANDSAT-7

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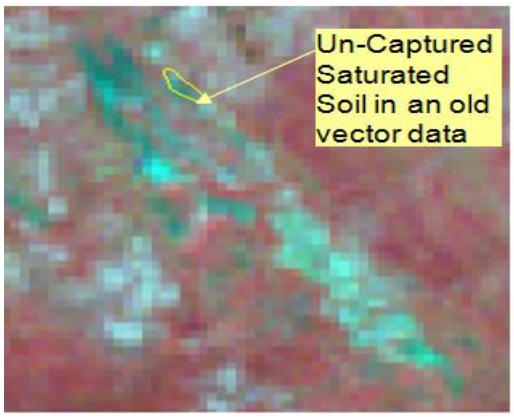


Fig-10.1

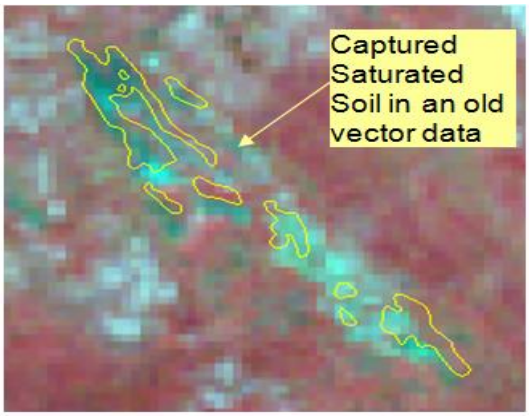


Fig-10.2

Vegetation (VG)- In Fig-11.1 there is vegetation which looks red in FCC and were not present in an old vector database while Fig-11.2 shows the presence of vegetation which has been captured during Updation by taking reference from LANDSAT-7 orthoimage.

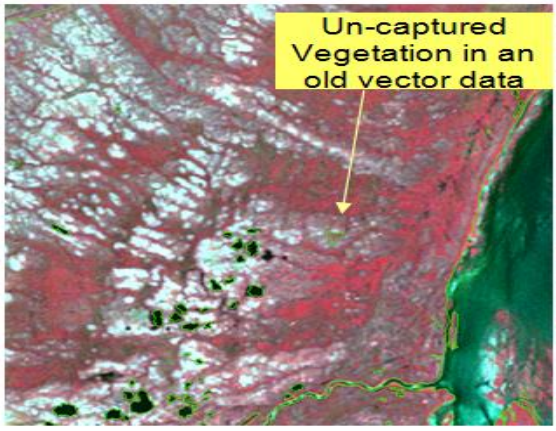


Fig-11.1

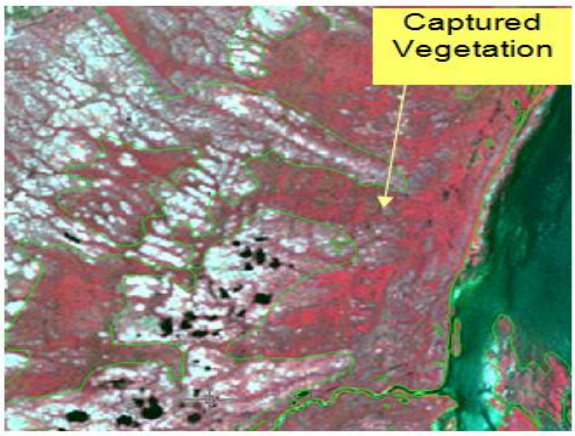
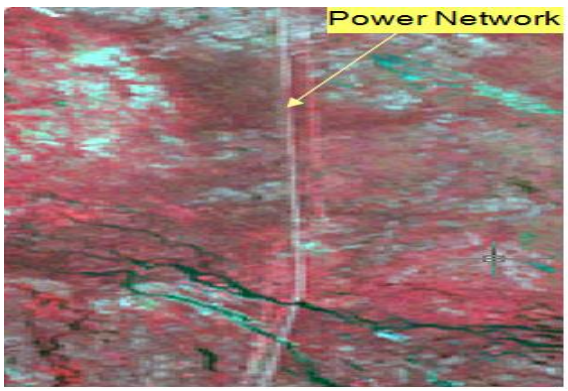


Fig-11.2

Power Network (PN) Fig-12.1 shows power network which is not present in old vector database and in Fig-12.2 this power network has been captured during Updation.



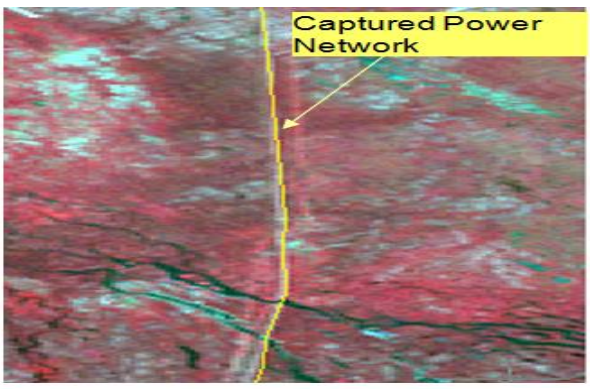


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Fig-12.1 Fig-12.2

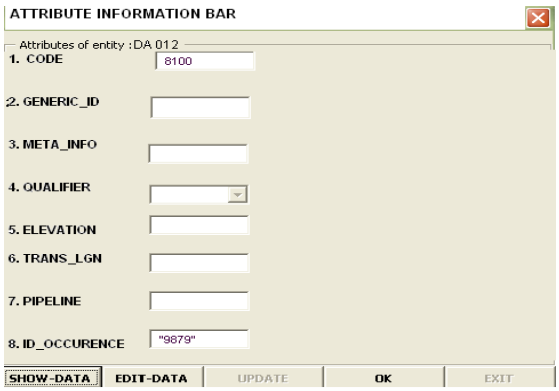
Code Updation

Each and every entity or feature has already assigned some specific code. During feature Updation, if there's any change in the existing entity then there code need to be updated as per the requirement as shown in the table of attribution of identifier-

4.1 Variable Attributes

The information on the source material can generally be used to identify the value to assign to variable attributes. The authorized domain of variable attribute values is defined in the following table

4.2 Entity and Entity Occurrence



Tabel-3 Attribute information table (where code Updation has to be done)

GENERIC_ID Attribute- If applicable, this attribute contains the value of the generic identifier associated with official airfields. The GENERIC variable represents the type of aviation infrastructure, which may have Airport, Heliport, Hospital heliport etc.META_INFO Attribute This attribute contains the value of the metadata identifier associated with the feature. QUALIFIER Attribute- This attribute contains the value of the geometric representation qualifier associated with the feature. ID_OCCURRENCE Attribute- This attribute contains the value(s) of the topographic database identifier(s) associated with the feature. NOTE- There is a separate attribute table for each and every attribute on which basis codes are assigned.

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Attribution of Identifiers

Each identifier in the original topographic database file must be returned in one form or another, even if the corresponding LANDSAT-7 occurrence must be deleted. This condition does not apply to identifiers for features that are not valid in LANDSAT-7 data, such as buildings and campgrounds. Partial deletion of an occurrence must be regarded as a modification of geometry. Each occurrence of a topographic database entity has a unique identifier recorded in the ID_OCCURRENCE field. Each occurrence of a LANDSAT-7 entity must be attributed the identifier for the corresponding occurrence of the topographic database entity. The data must be manipulated so as to minimize the creation of new occurrences and attribute the maximum number of topographic database identifiers to valid LANDSAT-7 occurrences. The resulting LANDSAT-7 identifier is recorded in the ID_OCCURRENCE field.

LANDSAT 7 Data		ID_OCCURRENCE
Complete Deletion		Maintain the vector database identifier in a negative form.
Confirmation		Identifier should be same for entity
Transfer		Identifier should be same for entity
New Capture		The identifier for a new occurrence is "0" (zero).
Geometry Modification	**Change of Shape or Size**	Identifier should be same for entity
	Chaining	The entity identifier shall be comprised of the vector database identifiers of all the chained entities, separated by a slash ("/").
	Segmentation	Maintain the topographic database identifier on each new segment.
	Change in Geometry	The deletion of the original occurrence, followed by a new capture.
Code Modification	(within one theme)	Identifier should be same for entity

Table-4 Showing assignment of Id_Occurrence during Updation

Results & Discussion

The final output is updated vector database with valid codes and entities which is extracted from the Landsat-7 orthoimage. This is the vector updated database which is cross checked after the planimetric accuracy. And a good significant level of planimetric accuracy is achieved under permissible limits of accuracy. All the altered entities such as communication lines, water bodies, vegetation area, soil are stored in the updated vector datasets which is shown in figure 13.

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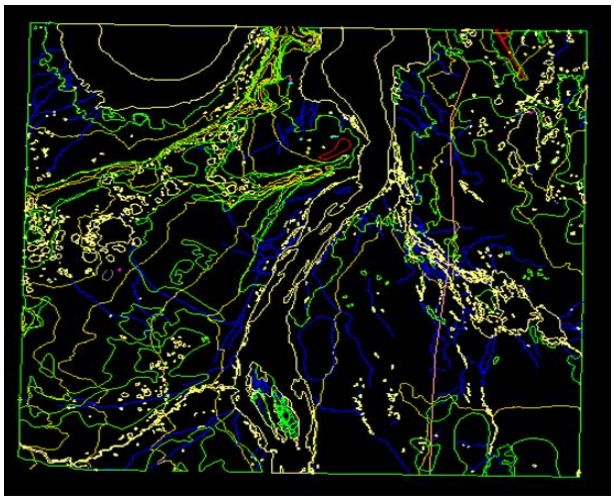

Figure 13: Final output is updated vector database

Conclusion

Finally, all the extracted features are cross validated with existing database in form of point, line and polygon. So after attaining certain accuracy level maps are updated on vector data base so that different entities can be easily interpreted. And on those features where some errors are monitored and user at their level can correct it and that file will be automatically will save in a list file. As a end product of this study is a updated form of cross verified topographical maps with less errors because distortions and changes which occurred over a period of time has been updated on the vector data base. The relevance of the studies depends upon updation of topographical maps because now a day's demand of more accurate land records data is needed in the field of agriculture, web based cartography, land use land cover mapping for future planning of expanding cities and special needs grabs the attention of country planners in master plans of a cities.

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