Updating of Road Network using Image Processing and Remote sensing Techniques

K. S. Prabhakar, N. Sathya, B. Subhashini

Abstract- The study utilizes the development of remote sensing techniques to use the satellite imageries to constantly monitoring the state of road networks and also provides the tool to map these road networks and even plan for new ones. In this context, the objective of this study is to update the road network map of Tirunelveli city, located at the Tamil Nadu, India. This study uses the semi-automatic method to extract the road network from satellite imageries. Road mask is defined in this research as a mask of road pixels, which are discriminated from others using commercial remote sensing software. Road seed is defined in this research as a directional point, indicating that a road is passing through the point along the direction. Road seeds are extracted from edge pixels. Road line extraction is conducted in a semi-automatic way by using Mean Shift Algorithm. The extracted road networks from the satellite imagery will be compared with the existing topographic and roadmaps by doing overlay process. Then the changes will be identified and analyzed. Many new roads which are not present in the existing roadmap will be updated and a new road network map could be obtained to utilize for the further planning and development of the city.

Keywords: GIS, Remote Sensing, Mean Shift Algorithm, Semi-automatic road network extraction, High resolution satellite image, PAN, IRS

I. INTRODUCTION

Social and economic development of a nation depends on availability of good transportation network.Tourism as an important sector of a national economy depends heavily on good transportation network and system. The state of transport infrastructure of any nation gives an indication as to the level of development of the nation. Many socio-economic activities that enhance the life of a people depend on availability of good networks of roads, railways, waterways, etc. When these infrastructure fail or are threatened by forces of nature, many social activities that depend on them are also affected.

Continuous mapping and monitoring of the state of these infrastructures help to identify areas of failure and thus lead to the development of proper control and maintenance measures. Ground transportation networks consist mostly of roads, scattered railways and few waterways. However, road transportation remains the most prominent system of transport in developing countries**.** A good transportation network is essential for the economic and social development of any nation.

A. Ground Surveying:

In the beginning, Ground surveying was used to obtain the road datasets. Ground surveying can be conducted using the devices such as receivers for Total station or the Global Positioning System.

Ground Surveying is extremely a time consuming process, since a surveyor has to obtain and serious of physical ground measurements along the road being extracted. And in the bad weather conditions ground surveying is not possible.As it is considered less resource intensive, extracting roads from the remotely sensed imagery could result in reduced costs and data acquisition time.

B. Road Extraction

Delineating roads from the remotely sensed data is known as "road extraction". It can be categorized as manual, semi-automatic and fully automatic process.

- Manual extraction entails a human operator to delineate roads from remotely sensed imagery.
- Semi-automated process need some human inputs to guide a set of automated process.
- Fully automated process requires no human input, these systems comprise variety of algorithms

C. Objectives

1. To extract the road network from the satellite sensor data using "semi-automatic road line extraction".
2. To extract the road network from the secondary data such as SOI maps and road maps.
3. To update road network of the city.
4. To validate the road network with the Ground truth.

D. Study Area Description

Tirunelveli is located at 8°44′N 77°42′E / 8.73°N 77.7°E. It has an average elevation of 47 meters MSL. Tirunelveli spread across 6823 sq.kms and is located in the southern-most tip of the Deccan plateau. Tirunelveli is an important junction in the National Highway No 7 connecting India from the North to South (Kashmir to Kanyakumari). The nearest pivotal towns are: Gangaikondan in the north, Tuticorin in the east, Sengottai and Alangulam in the west, Kalakkad in the southwest and Nanguneri in the south.The city is located on NH 7, 150 km to the south of Madurai and 91 km to the north of Kanyakumari. NH 7A, an extension of NH 7, connects Palayamkottai with Tuticorin Port. Now 4 lane road and NH 7A stretch have been finished. Tirunelveli is accessible by road from Madurai or Nagercoil. Tirunelveli is also connected by major highways to Kollam, Tiruchendur, Rajapalayam, Sankarankovil, Ambasamudram and Nazareth. The location map of the study area is indicated in Figure 1.

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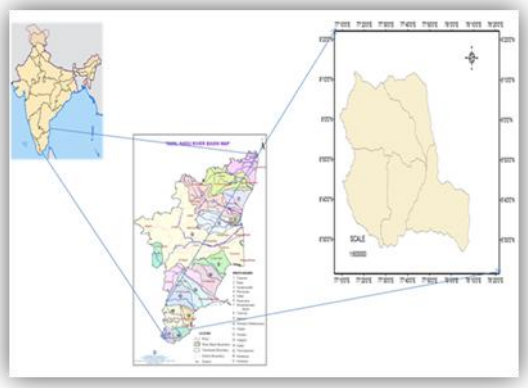

Figure 1: Location Map

II. MATERIALS and METHODS

The adopted methodology is depicted in Figure 2. Under this various data and its descriptions are given. And the methods used are given in detail.

A. Data Used

1) Topographic map

A topographic map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines. The topographic maps used are 1: 50000 scale of 58H06, 58H10, 58H14[Survey Of India, Chennai].

2) Transport Network Map

A Transport Network of map of the city shows all the means of transportation present in that city such as road networks, railway networks etc. Transport network map with the scale of 1:25000 was used for this study. It is shown in Figure 3.

3) Remote sensing data

The satellite data used in this study are IRS P5 PAN (2011) [National Remote Sensing Centre, Hyderabad]. IRS P5 satellite data and its description are shown in Figure 4 and

Table 1 respectively.

Satellite ID	IRS-P5
Orbit	Sun synchronous
Sensor	PAN
Path & Row	350 & 355
Spatial Resolution	2.5 m
Radiometric Resolution	10 bits
Swath [PAN Fore] [PAN Aft] 27 km	30 km

Table 1: IRS P5 Data Description

B. Methods

1) Road Mask

A road mask is a "Binary Image", where with pixels suggest that a road like object is most probably over there. The road mask is exploited in road line extraction. Canny Filter is used to produce the road mask. Edge pixels extracted by this filter shows boundaries of roads, buildings, rivers.

2) Road Seed

A "Road seed" is defined as a directional point, indicating that a road is passing through the point along the direction. Road seeds are extracted by tracing edge pixels, as a long edge line with only a slow change of direction suggest a road or river passing through.

3) Road Line Extraction

At the beginning, a starting point is specified by the operator. A road line is extended from the starting point in an iterative way, where in each iteration, template of a pre-defined width and length is rotated at one of the terminal point of the road line and matched with the integrated image of road mask and road seed to find the next road line point. At this point, the operator examines whether the road line is correct, or run to a wrong direction or loss its way in a local maximum. A control point is assigned whenever necessary by the operator to guide the road line extraction. Most often appeared directions $\alpha 1$, $\alpha 2$are estimated where $\alpha 1 \in [0,360]$ and $\alpha 2 \in [\alpha 1 - \Delta \alpha, \alpha 1 + \Delta \alpha]$, where $\Delta \alpha$ is a permissible curvature of road line.

4) Mean Shift algorithm

Mean Shift algorithm can be summarized as

1. Use kernel density estimator(weighted average e.g.Gaussian) to shift the means of pixels in the image
2. Stop when each mean sequence has converged
3. Use the converged means to delineate segments
4. Basically a pair of pixels belongs to segment if their convergence color and spatial components are within some given range
5. For segments with fewer pixels than a given threshold, place them into neighboring segments

5) Georeferencing

To georeference something means to define its existence in physical space. That is, establishing its location in terms of map projections or coordinate systems. When data from different sources need to be combined and then used in a GIS application, it becomes essential to have a common referencing system. The study area was georeferenced using the geographical coordinates (lat, long) by keeping topographic map as a reference.

6) Digitization

Digitization is the process of capturing the spatial data on a map manually and storing them into a computer file. The spatial features, namely points, lines, polygons that constitute a map, are converted into x and y coordinates. The GIS software used for digitization and spatial analysis in the present study are ArcGIS 10.1. It is raster based software with multiple map analysis capabilities.

7) Overlay Analysis

Overlaying is an important procedure in GIS analysis. Overlay analysis c.an be used to combine the characteristics of several datasets into one. Specific locations or areas that have a certain set of attribute values—that is, match the criteria specified can then be identified. This approach is often used to find locations that are suitable for a particular use or are susceptible to some risk. In general, there are two methods for performing overlay analysis—feature overlay (overlaying points, lines, or polygons) and raster overlay. In raster overlay, each cell of each layer references the same geographic location. That makes it well suited to combining characteristics for numerous layers into a single layer.

8) Comparison with Existing Maps

The extracted road networks from the satellite imagery will be compared with the existing topographic and roadmaps by doing overlay process. Then the changes will be identified and analyzed. Many new roads which are not present in the existing roadmap will be updated. Thus a new road network map can be produced.

III. RESULTS AND DISCUSIION

Using the PAN satellite data road network is extracted by semi-automatic method, which will be utilized to update the road map of the city.

A. Extracting a road line

The road line is extractedby assigning a seed point in the road line of the satellite image, which is used for template matching. A road mask which shows the edge pixels of the roads which present in the image. This road mask is explioted in roadline extraction.The road network is extracted form transport network of the city and SOI topo maps by accurate manual digitization.

B. Computed Results

Using Overlay Analysis, the road network layers from the PAN image and digitized road network from the existing transportation network map were compared and analyzed. The comparison is used to update the road map of the city. Shadowed area can be justified along with the field survey points. GPS receiver and collection of GPS points are shown in Figure 5.

IV. CONCLUSION

In this study, a semi-automatic road extraction method is proposed to create and update road maps in urban/suburban area using high resolution satellite images.This paper demonstrates the feasibility of template matching. A road mask suggests that a road like object is most probably over there. The road mask and road seeds are exploited in road line extraction. Mean Shift Algorithm produces good accuracy than others methods. This method is valid in extracting main roads in high dense building area. It is very much useful for urban planning.

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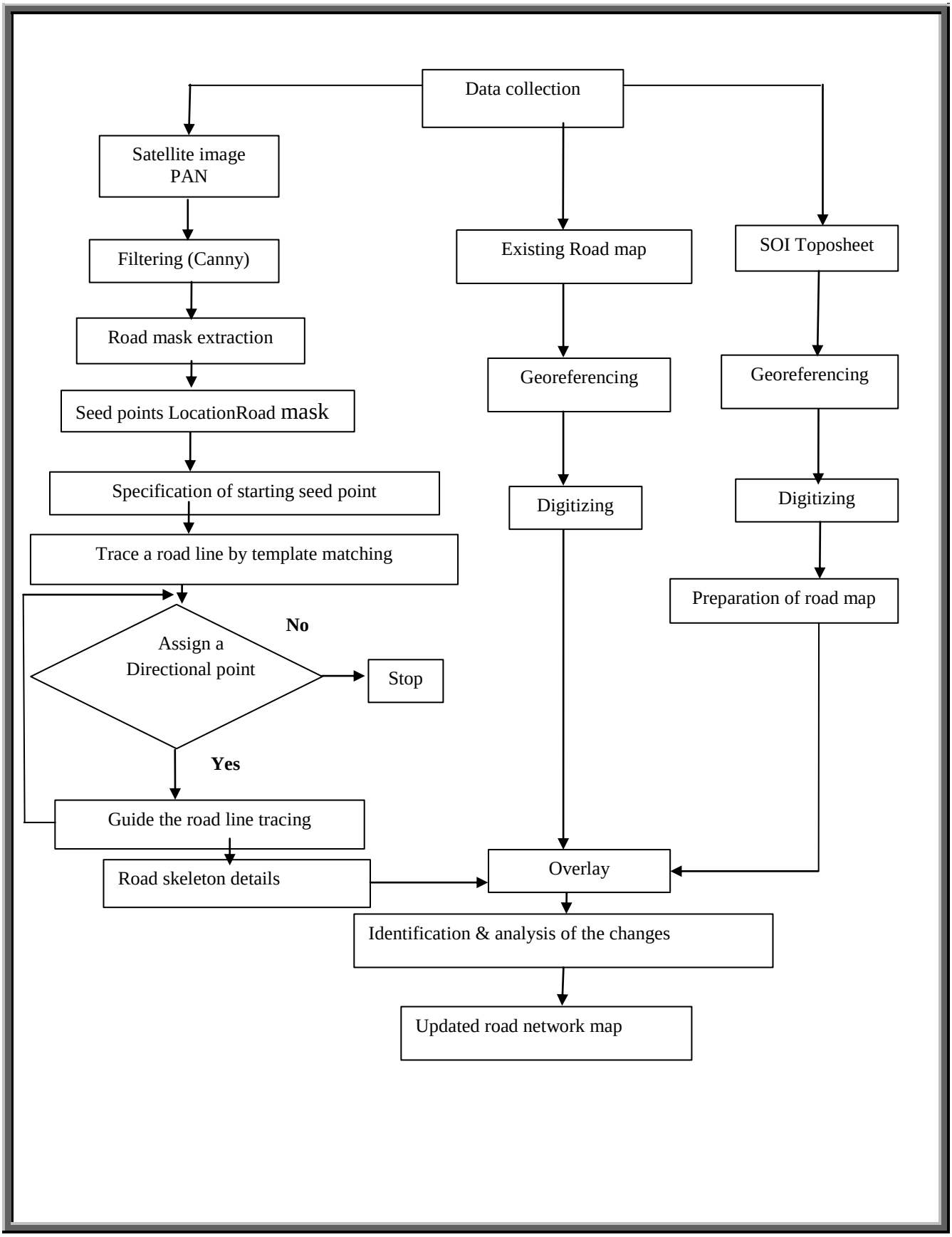

Figure 2: Methodology Flow Chart

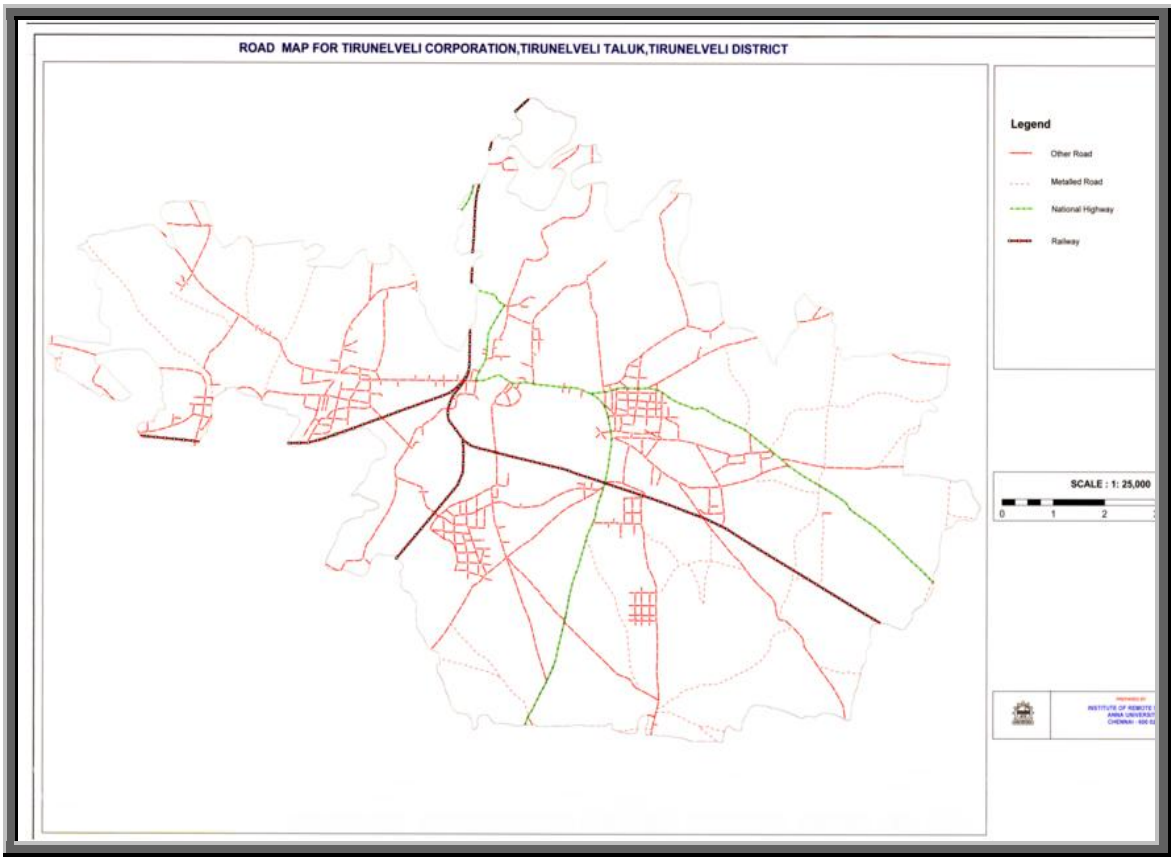

Figure 3: Transport Network Map of Tirunelveli Corporation

Figure 4: IRS P5 PAN Data

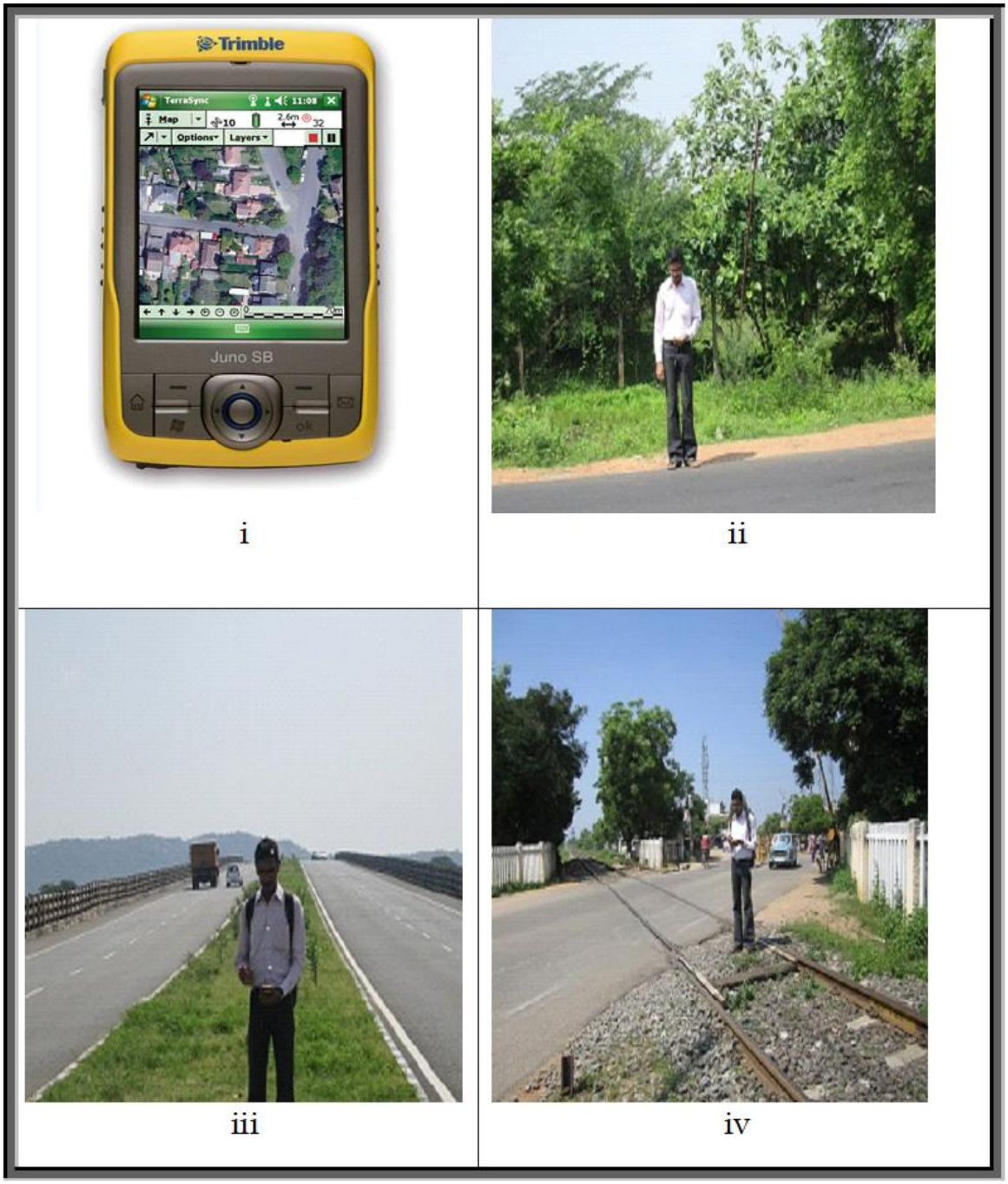

Figure 5: (i) GPS Receiver(ii) (iii) (iv) Collection of GPS points at various places of the city