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Identifying Error Sources in Elevation Data Using GPS

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ABSTRACT: *Tracking the three dimensional position using GPS or other equivalent technologies is an increasing important feature in many applications like surveying, mapping, transportation, agriculture, military planning, GIS and others. The positional and elevation accuracy of any place is tend to error due to various factors including poor geometrical position of satellites, weather changes in ionosphere and troposphere layer, multipath effects and so on. This inaccuracy may affect various real time navigational systems and position finding systems. The 3D positional accuracy can be increased significantly by other supporting data from other receivers, and low cost sensors like accelerometer, magnetometer, and air pressure sensors. The third dimension, altitude can augment the positional solution by improving the elevational accuracy. So this research paper aims in building a prototype system suitable for data collection from various receivers and sensor devices*
KEYWORDS: *GPS, 3D Map matching.*

I. INTRODUCTION

Global Positioning System is a satellite based navigation system made up of a network of 24 satellites from 1960-1982. The process of translating the measured GPS positions onto the digital map or road map is known as map matching. GPS based map matching have been the focus of researchers for many years to improve the accuracy level by various approaches. The most common approaches are, Geometric approach (Kim et al., 1996), Topological approach (Velaga et al., 2009), Probabilistic approach (Ochieng et al., 2003), Kalman Filter (Jo et al., 1996) and Fuzzy logic model (Kim et al., 1999). The accuracy of 2D algorithms has been improved significantly with the development of above said algorithms. The corner stone of these approaches is that the absence of third dimension, elevation. 3D maps have recently made their way into mass production and are becoming a common feature in all navigation systems as well as in mobile phones (AireOlesk et al., 2009). This shows that the current focus must be in 3D map matching to support the accurate positioning.

Indian Status:

IRNSS(Indian Regional Navigational Satellite System) an autonomous regional satellite navigation system being developed by the Indian Space Research Organization (ISRO) which would be under total control of Indian government. The requirement of such a navigation system is driven by the fact that access to Global Navigation Satellite Systems, GPS, is not guaranteed in hostile situations. The IRNSS would provide two services, with the Standard Positioning Service open for civilian use and the Restricted Service, encrypted one, for authorized users (military). The System is intended to provide an absolute position accuracy of better than 10 meters through- out Indian Landmass. The United States and India issued a Joint Statement in 2007 establishing cooperation on GPS and GPS augmentations. The cooperation expands upon existing efforts to ensure interoperability between GPS and India's GPS And GEO-Augmented Navigation (GAGAN) system. Hence the researchers can make use of IRNSS in future to improve the accuracy in map matching.

International Status:

GPS is used to be an umbrella term for satellite navigation system. But it is owned by U.S Navstar system. There are some other systems exist GLONASS(Russia), COMPASS(China) and Galileo(Europe). Other Regional navigation systems are BeiDou(China), IRNSS(India), and QZSS(Japan). The United States and Australia initiated a cooperative relationship on GPS and GPS augmentations through a Joint Delegation Statement signed in 2007. The cooperation expands upon existing efforts to ensure interoperability between GPS and Australia's Ground Based Augmentation System (GBAS).In 2010, the United States and China concluded technical coordination discussions on radio frequency compatibility between China's BeiDou System (BDS) and GPS.With the development of Satellite Navigation Systems and the high precision reality based 3D maps, 3D map matching is the best solution for next generation navigation system. The specific objective of this research paper is to collect data from GPS and other sensor devices and develop an algorithm to identify error

sources in collected data and to remove the error. Hence the rest of this paper is structured by the sections Proposed Methodology, Results and Conclusion and Future Work.

II. PROPOSED METHODOLOGY

A tool is developed to collect data from the device, parse the data from the file with .gpx extension and store the trajectory data in the data base. From the data stored in the database, the outliers in the elevation data identified and rectified in the data base. The outputs of the data were analyzed using Google Earth. Fig.1 shows the flowchart of the proposed methodology.

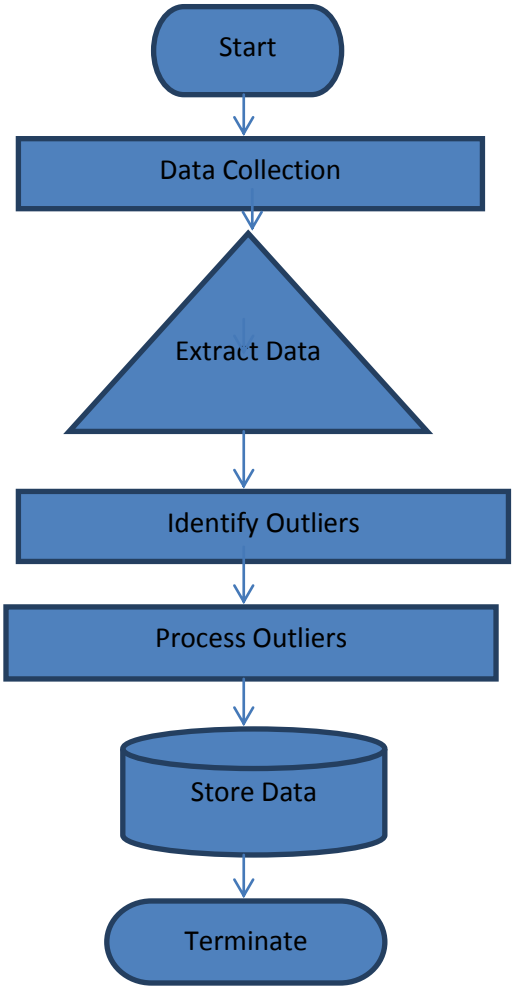

Figure 1. Proposed Methodology.

The tool is developed in Java by using Eclipse Juno IDE and MySql is used for data base storage. Fig. 2 shows the sample data in xml format with the extension of .gpx.
Table I shows the extracted data from the .gpx file.

Table 1. Extracted Data

Timestamp	Latitude	Longitude	Elevation
2018-05-08T13:43:44Z	80.2097683679	13.1711167842	105.40
2018-05-08T13:43:58Z	80.2097688708	13.1711177062	106.36
2018-05-08T13:44:18Z	80.2097691223	13.1711166166	106.84
2018-05-08T13:44:49Z	80.2097695414	13.1711157784	107.81
2018-05-08T13:45:04Z	80.2097695476	13.17111068098	108.77

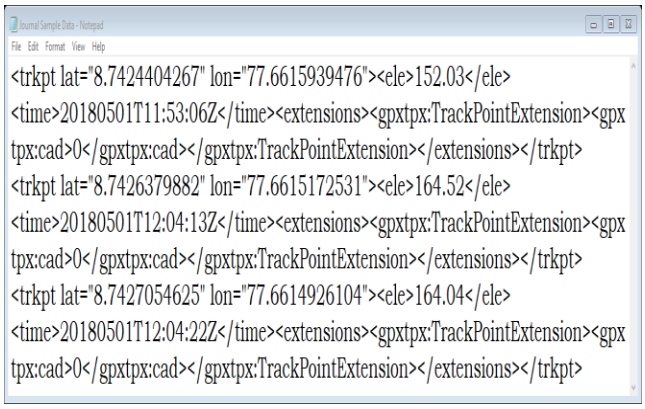

Figure.2 Data in XML format

The first step in any statistical data analysis is to check whether the data are appropriate for the analysis. In such analyses, the presence of outliers appears as an unavoidable important problem. Thus, in order to manage the data properly, outliers must be defined and treated. [10]. To define and treat outliers, the following steps have been implemented in the tool.

1. Arrange the data in data set in sorting order
2. Calculate the Median of the data set
3. Calculate the Lower Quartile(Q1) and Upper Quartile(Q3)
4. Calculate the inter quartile value
5. Fix the inner boundary and outer boundary for the data set
6. If the data lies outside the inner boundary, it can be considered as Minor Outlier
7. If the data lies outside the outer boundary, it can be considered as Major Outlier

The following sample data have been collected, and analyzed for outliers by using the tool developed.

Step 1: Table 2. Elevation Data

Elevation Data(Collected)	Elevation Data(Sorted)
105.40	105.40
106.36	106.33
106.84	106.36
107.81	106.45
111.32	106.78
106.97	106.84
107.65	106.97
106.33	107.11
106.45	107.65
107.11	107.81
107.89	107.89
106.78	111.32

Step 2:

Median =(106.84+106.97)/2
= 106.91

Step 3:

Q1 = (106.36+106.45)/2
= 106.41
Q3 = (107.65+107.81)/2
= 107.73

Step 4:

Inter Quartile Value = Q3-Q1
= 107.73-106.91
= 0.82

Step 5:

Inner Boundary: = 0.82*1.5
=1.23

Hence Inner Boundary Range is 108.96(Q3+1.23) and 105.18(Q1-1.23)

Outer Boundary: =0.82*3
=2.46

Hence Outer Boundary Range is 110.19(Q3+2.46) and 103.95(Q1-2.46)

Step 6 & 7:

In this collected sample data, 111.32 lies outside the inner boundary as well as the outer boundary. Hence this is the only outlier identified in the collected sample data.

III. RESULTS

The identified error source in the collected sample data is highlighted in the Table III and the graphical representation of the data is given in Fig. 3

Table 3. Elevation Data with Outlier

Elevation Data(Collected)	Elevation Data(Sorted)
105.40	105.40
106.36	106.33
106.84	106.36
107.81	106.45
111.32	106.78
106.97	106.84
107.65	106.97
106.33	107.11
106.45	107.65
107.11	107.81
107.89	107.89
106.78	**111.32**

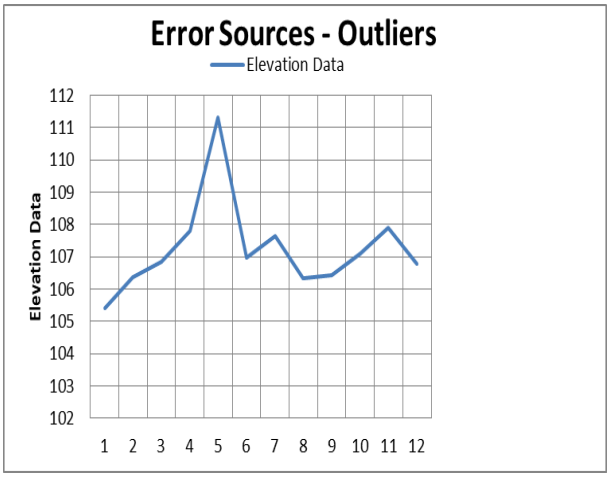

Figure.3 Error Sources - Outliers

IV. CONCLUSION AND FUTURE WORK

In this research work, data have been collected from various satellite networks using the device Oregon 650, a Garmin Product under various scenarios. The tool has been developed to extract the data from the raw data in xml format and store it in a relational data. Statistical analysis is implemented in the tool to identify the error sources of collected data. The tool is tested with voluminous data and expected result is achieved.

In future, the research can be enhanced with eliminating or rectifying the outliers and matching the data using 3D map matching with advent of emerging technologies

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