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# Simple Model for Coding Geographic Location Coordinates

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**Abstract**— In the recent years, object location becomes a major part of mobile devices and a lot of device services depend on the current location of the device. Also, there are applications like health care applications, need historical location data. Dealing with the historical location data will issue two main points: the first is a large storage space is needed for these data and the second is the desired location accuracy requirement should be defined. Ignoring these two points and storing the location data as it is received from the GPS sensor will result in west of storage resource because of data redundancy and over accuracy. This simple model deals with both redundancy and desired accuracy of the location data. After determining the desired accuracy for the latitude/longitude coordinate parameters, the system starts to code this set of location data using simple predictive coding scheme. This simple proposed method gives in some cases 1:25 compression ratio.

**Index Terms**— GPS, Location data compression, Location data coding

## 1 Introduction

Object movement and location is a fundamental service in mobile sensing. Data samples used by outdoor applications, such as personal health and wellness applications, are commonly tagged with patient locations depending on GPS data that has been received [1]. For anyone with a GPS receiver, the system will provide location and time. GPS provides accurate location and time information for an unlimited number of people under any weather conditions, day and night times, anywhere in the world using a set of satellites in the atmosphere. These satellites act as instantaneous reference points from which receivers on the ground detect their position. The fundamental navigation principle is based on the measurement of pseudo ranges between the user and, at least, three satellites [2], [3]. Recent mobile sensing applications, especially those leveraging participatory sensing paradigms, typically use smart phones as sensors [1].

GPS data is commonly presented in simple NMEA sentences which contain information such as latitude, longitude and altitude. GPS device output sentences many times a minute, and therefore a set of output data will be generated. Systems that consist of number of entities far from each other need to transfer these generated location data periodically depending on the system's application requirements. As an example safety applications require that vehicles share their positions and trajectory with other nearby vehicles. This is typically envisioned through periodic broadcasts of GPS coordinates over a dedicated short range communications channel [4], [5]. For such a system not only current position is important but also a set of historical positions. The transfer of these data is still considered a challenge due to their huge size, store these data also considered another challenge as the databases in the past has been designed to always keep snapshot of current data and their present support for spatial time series is at best rudimentary [6], Shi and Qiao [7] referred referred that the commercially available GPS receivers are not accurate and they are area dependent. Even for the fixed point the GPS measured positioning error about 0.234 meter could be observed for a period of time. They referred that of 12 GPS measured distance errors, only one is about 5.7 meters, all others are within the range of formal models can be used for movement predictions of particular objects based on previous position measurements, exploiting the redundancy and predicta-bility of movements [8].

In some cases the position based application requires determination of the location in a specific accuracy which is less than the provided accuracy by the GPS receiver. For example consider the security application for monitoring vehicles, this application need to determine a vehicle location and since the typical vehicle dimensions is around 10 ft x 5 ft, any location accuracy less than these dimensions is considered to be over fitting and west of resources and traffic.

The next section of this paper will introduce a proposed simple method to compress GPS data and at the same time guarantee the desired location accuracy.

## 2 Method Model

Since GPS data are represented using double precision format for the latitude and longitude of one point, so the system needs 128 bits for representing the location (i.e. latitude/longitude data), or even the system may use 64 bits instead of 128 bits, this amount of bits will be a major problem if there is need to transfer (or achieve) the location data frequently. On the other hand as mentioned before in some cases we may need a certain degree of accuracy which is less than the provided location accuracy by the system. Since, the simple rounding of these values may produce nondeterministic error in retrieving desired accuracy, so we proposed a simple model to compress these data during the transmission periods and depending on the desired location resolution.

The method consists of two stages: (i) Set Accuracy and (ii) Make Prediction. For the first stage there are three input values: latitude, longitude and distance resolution (desired accu-

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racy). For each coordinate we will compute the Xcount and Ycount variables, which will be the input to the second stage. If we adopt the ellipsoidal model for representing the Earth surface, then the distance (R) from Earth center to the point (θ, λ) on Earth surface could be determined using:

$$R = \sqrt{A^2 \cos^2(\theta) + B^2 \sin^2(\theta)} \quad (1)$$

In which A= 6378137.0 and B= 6356752.314245 according to WGS84 ellipsoidal model [7], the symbol θ represents the Earth latitude coordinates, λ is the longitude. Depending on R (i.e. radium at latitude L) the separation distance (Sx) between the meridian lines and distance (Sy) between latitude lines could be determined using the following:

$$S_y = 2\pi R/360 \quad , \quad S_x = S_y \cos(\theta) \quad (2)$$

Where Sy is the separation distance between latitude lines and Sx is the separation distance between meridian lines.

Then we can compute the relative horizontal distance counts (Xcount) and vertical distance counts (Ycount) depending on the desired resolution and computed values:

$$X_{count} = round\left(S_x(\lambda - \lambda_{ref})/D_{res}\right) \quad (3)$$

$$Y_{count} = round\left(S_y(\theta - \theta_{ref})/D_{res}\right) \quad (4)$$

Where (θref, λref) are the coordinates of a reference point; it could be assigned by the user, Dres is the required resolution of the determined distance.

A set of location data (Xcount, Ycount) can be send periodically beside to be saved on the mobile storage media, so with each transmitted frame we will have a set of Xcount and Ycount.

In the second stage a simple prediction coding model is applied on the location data to compress the data before transmission. In perspective of the system this compression will be lossless. The delta coding model is selected as a predictive model due to its simplicity and low computation load requirements. According to delta coding the coded values are:

$$\Delta X_{count}(i) = X_{count}(i) - X_{count}(i-1) \quad (5)$$

$$\Delta Y_{count}(i) = Y_{count}(i) - Y_{count}(i-1) \quad (6)$$

## 3 Experimental Results

The method has been applied on the various location data, using Android 4.0.4 mobile operating system with Samsung internal GPS receiver; the table (1) presents the necessary information about the captured GPS data.

TABLE 1
LOCATION DATA

| Sample Place | Inside car with speed about 20-40KmpH | Inside car with speed about 40-80KmpH | Inside car at crowded street | Standing in same position |
|---|---|---|---|---|
| Period time (Minute) | 4:05 | 4:58 | 24:04 | 3:31 |
| # of received data | 40 | 91 | 75 | 9 |
| Latitude Standard Deviation | 0.01358 | 0.04098 | 0.00939 | 0.00005 |
| Longitude Standard Deviation | 0.01017 | 0.09096 | 0.00345 | 0.00005 |

As appeared in the last two rows of table (1) the standard deviations of all samples is always less than 0.01 which means the distribution of location data within each period of time is small. By applying the proposed method on the captured GPS samples the attained results are those shown tables (2-5):

TABLE 2
INSIDE CAR WITH SPEED ABOUT 20-40KMPH

| Sample Place | Latitude 64 bps | Latitude 32 bps | Longitude 64 bps | Longitude 32 bps |
|---|---|---|---|---|
| # of bits (original size) | 2560 | 1280 | 2560 | 1280 |
| # of bits (DisRes 1 meter) | 295 | 295 | 296 | 296 |
| Compression Ratio | 0.12 | 0.23 | 0.12 | 0.23 |
| # of bits (DisRes 10 meter) | 175 | 175 | 176 | 176 |
| Compression Ratio | 0.07 | 0.14 | 0.07 | 0.14 |

TABLE 3
INSIDE CAR WITH SPEED ABOUT 40-80KMPH

| Sample Place | Latitude 64 bps | Latitude 32 bps | Longitude 64 bps | Longitude 32 bps |
|---|---|---|---|---|
| # of bits (original size) | 5824 | 2912 | 5824 | 2912 |
| # of bits (DisRes 1 meter) | 652 | 652 | 833 | 833 |
| Compression Ratio | 0.11 | 0.22 | 0.14 | 0.29 |
| # of bits (DisRes 10 meter) | 379 | 379 | 470 | 470 |
| Compression Ratio | 0.07 | 0.13 | 0.08 | 0.16 |

TABLE 4
INSIDE CAR AT A CROWDED STREET

| Sample Place | Latitude 64 bps | Latitude 32 bps | Longitude 64 bps | Longitude 32 bps |
|---|---|---|---|---|
| # of bits (original size) | 4800 | 2400 | 4800 | 2400 |
| # of bits (DisRes 1 meter) | 392 | 392 | 394 | 394 |
| Compression Ratio | 0.08 | 0.16 | 0.08 | 0.16 |
| # of bits (DisRes 10 meter) | 168 | 168 | 242 | 242 |
| Compression Ratio | 0.04 | 0.07 | 0.05 | 0.1 |

TABLE 5
STANDING IN SAME POSITION

| Sample Place | Latitude 64 bps | Latitude 32 bps | Longitude 64 bps | Longitude 32 bps |
|---|---|---|---|---|
| # of bits (original size) | 576 | 288 | 576 | 288 |
| # of bits (DisRes 1 meter) | 39 | 39 | 55 | 55 |
| Compression Ratio | 0.07 | 0.14 | 0.095 | 0.19 |
| # of bits (DisRes 10 meter) | 27 | 27 | 28 | 28 |
| Compression Ratio | 0.05 | 0.09 | 0.05 | 0.1 |

## 4 CONCLUSIONS

Depending on the analysis results some relevant remarks have been stimulated:

- The attained CR depends on the distribution of data and changing in the values of latitude and longitude, which means the less the SD is the better the CR is.
- The method works better on longer periods which mean more location data gives more compression. For instance the longitude SD of the sample set (4) and sample set (3) are 0.00005 and 0.00345 respectively, but the CR of sample set (3) is more than for sample set (4); because of more location data exist and small change in their values.
- The method depends directly on the desired resolution; the greater the resolution is the better Xcount and Ycount values are, and these two values affects the result of the second stage.
- The attained latitude and longitude compression are not always same; they depend on the direction of movement, if the object movement is from east to west or vice versa this means that the compression result of latitude will be more than of longitude as it is appeared clearly in table 3.



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