

An Online Compression Algorithm for Positioning Data Acquisition

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Positioning data are usually acquired periodically and uploaded to the server via wireless network in the location data acquisition systems. Huge communication overheads between the terminal and the server and heavy loads of storage space are needed when a large number of data points are uploaded. To this end, an online compression algorithm for positioning data acquisition is proposed, which compresses data by reducing the number of uploaded positioning points. Error threshold can be set according to users' needs. Feature points are extracted to upload real-timely by considering the changes of direction and speed. If necessary, an approximation trajectory can be obtained by using the proposed recovery algorithm based on the feature points on the server. Positioning data in three different travel modes, including walk, non-walk and mixed mode, are acquired to validate the efficiency of the algorithm. The experimental results show that the proposed algorithm can get appropriate compression rate in various road conditions and travel modes, and has better adaptability.

Povzetek: Predstavljen je nov algoritem za zajemanje podatkov o realnem času, uporaben za sisteme za določanje položaja.

1 Introduction

With advances in tracking technologies and the rapid improvement in location-based services (LBS), a larger amount of location data needs to be collected [1]. These positioning data are linked up in chronological order to form a trajectory which contains a sequence of positioning data with latitude, longitude and timestamp. Trajectory can be used for positioning, navigation, providing some location-based services and expressing user geospatial history behaviour. For location acquisition systems, a large number of positioning data not only generate lots of communication overheads but also bring heavy burden for the storage system [2]. A major reason for this problem is that the uploaded data points are far more than necessary points [3]. Therefore, trajectory compression and simplification have received increasing concern.

Trajectory compression can be classified into two categories, offline compression and online compression. In the offline compression, all data points collected (usually on the server) are considered for compression regardless of the data transfer process. In the online compression, data points are processed before they are uploaded, and only feature points selected are transmitted to the server.

For the offline compression, Zhang et al. [2] proposed a trajectory data compression algorithm based on the spatial-temporal characteristic. In order to extract accurately trajectory information, the algorithm calculates the distance standard to judge the feature point according to the three-dimensional spatial-temporal characteristic of GPS data points. Given a trajectory $Traj$ and error threshold, the Douglas-Peucker Algorithm [4] constructs a new trajectory $Traj'$ by adding points from

$Traj$ repeatedly until the maximum spatial error of $Traj'$ becomes smaller than error threshold. The Douglas-Peucker algorithm has the limitation of ignoring temporal data. Top-Down Time Ratio (TD-TR) [5] overcomes this limitation by using *Synchronized Euclidean Distance (SED)* [6] instead of spatial error. The characteristics of the vehicle trajectory are described in the proposed algorithm [7], in which the advantages and disadvantages of judgment method with point by point and judgment method with multi-point joint are analysed. This algorithm puts forward the description method for trajectory based on turning point judgment method. Chen et al. [8] proposed a trajectory simplification algorithm (TS), which considered both the shape skeleton and the semantic meanings of a GPS trajectory. The heading change degree of a GPS point and the distance between this point and its adjacent neighbours in this algorithm are used to weight the importance of the point. By studying the model of temporal data in vehicle monitoring system, Wang et al. [9] proposed a modelling idea for establishing trajectory version. To reduce storage and improve temporal queries, spatial-temporal cube is segmented to form unit spatial-temporal cube by this modelling idea. With discussing some problems of trajectory data compression about road net, Guo [10] proposed a non-linear compression algorithm of moving objects trajectories based on road net.

The above offline algorithms have played a positive role in reducing amount of positioning points. However, they are only applied to the case that the start and end of the trajectory are clear. That is to say, compression begins only after obtaining all of the points from the input trajectory. That is why communication overheads

between the terminal and the server are huge and burdens of storage space are heavy. In recent years, some online compression algorithms have been proposed.

Similar to Douglas-Peucker, Opening Window algorithm [11] approximates each trajectory using an increasing number of points so that the resulting spatial error is smaller than the bound. This algorithm is a generalized online compression with a little delay, and it works without considering time data. Opening Window Time Ratio (OPW-TR) [5] is an extension to Opening Window which uses SED instead of spatial error. Compared to Opening Window algorithms, OPW-TR has the benefit of taking temporal data into account. However, just like Opening Window algorithm, OPW-TR also has a little delay. Both of them cannot real-time determine whether current point needs to be compressed. An algorithm called SQUISH (Spatial QUality Simplification Heuristic) [12] uses a priority queue where the priority of each point is defined as an estimate of the error that the removal of that point would introduce. SQUISH compresses each trajectory by removing points of the lowest priority from the priority queue until it achieves the target compression ratio. This algorithm is fast and tends to introduce small errors during compression. However, it cannot compress trajectories while ensuring that the resulting error is within a user-specified bound. It also exhibits relatively large errors when the compression ratio is high [13]. Yin et al. [14] proposed an algorithm and a restraining model for vehicle data stream transmission. It gives a formula for data recovery in the monitoring centre by discussing the determination condition of speed and direction change degree in the algorithm. However, this algorithm is suitable for the integrated system of monitoring and navigation, and must be matched to the map. Wang et al. [15] proposed an improved moving object model based on vehicle monitoring system of moving objects model. This model provides a dynamic time selection algorithm, which adjusts dynamically the time density according to object moving speed. Therefore, the number of communications is reduced effectively. However, this algorithm works regardless of data recovery and the issue that the moving direction affects the accuracy of the model. Han et al. [16] proposed an adaptive algorithm for vehicle GPS monitoring data. The speed function is expressed by using fitting polynomial with constraint based on endpoint speed and mileage. This algorithm considers the case that terminal with and without map, in which the deviation distance is used for denoting the deviation of speed direction. At the same time, data recovery algorithm, algorithm evaluation index and application mode of algorithm are proposed in this algorithm. However, it must be set speed threshold in advance according to the road. In practice, according to the different road, predetermined speed threshold is very difficult.

In this paper, an online compression algorithm for positioning data acquisition systems is proposed, which compresses the data points before transmission from terminal to the server. In this algorithm, the feature points are extracted and uploaded by computing the

change of speed and direction based on error threshold set according to the users' requirements, and non-feature points are discarded to reduce unnecessary data transmission and bandwidth occupation.

The remainder of this paper is organized as follows. Section 2 describes our new online compression algorithm for positioning data acquisition in detail. An experimental evaluation of trajectory compression algorithm is provided in Section 3. The paper concludes with future work in Section 4.

2 The online compression algorithm

In order to compress an original trajectory, the key of our algorithm is to pick out feature points. For each point collected in the terminal, the current point will be uploaded and preserved if it is a feature point, else it will be discarded as a non-feature point. If needed, the recovery trajectory that approximated to the original trajectory can be obtained by the recovery algorithm with the feature points on the server. Our algorithm involves feature points, non-feature points and lost points. A feature point is a positioning point that a large change in speed or direction; a non-feature point is a positioning point that is discarded with a small change in speed and direction; a lost point is a positioning point that is lost because the communication delay caused by the positioning signal blind area. Generally, original trajectory is a temporally ordered sequence of positioning points $P = \{p_1, p_2, \dots, p_n\}$, for $i = 1, 2, \dots, n$, $p_i = (lng_i, lat_i, t_i)$ where lng_i , lat_i represent the longitude and latitude of the i th point and t_i stands for the time stamp. For a point p_i , $p_i.lng$, $p_i.lat$ and $p_i.t$ denote longitude, latitude and time stamp of p_i respectively. For each positioning point p_i in an original trajectory, recovery point p_i' of p_i is a data point obtained by the recovery algorithm, which represents p_i in the recovery trajectory.

2.1 Algorithms

In the compression phase, error threshold and acquisition interval are set in advance according to accuracy requirements. The initial two collected points (these two points must be the feature points) are directly uploaded to the server without judgment. Starting from the third positioning point, corresponding recovery point is calculated for each point collected currently. The distance between the actual point p_i and its corresponding recovery point p_i' is compared with the error threshold. If larger than the error threshold, the current point is regarded as a feature point and uploaded. If not, the current point is abandoned as a non-feature point (see Fig. 1). Judgment is done for each point, and the last positioning point is uploaded until the end of the acquisition.

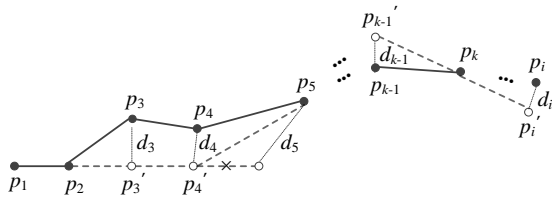


Figure 1: A schematic diagram for the compression process.

As shown in Fig. 1, $p_1, p_2, p_3, p_4, p_5, p_{k-1}, p_k$ and p_i are the original positioning points, each positioning point has a corresponding recovery point. p_1, p_2, p_5 and p_k are feature points, their recovery points are themselves. p_3', p_4' and p_{k-1}' are recovery points of p_3, p_4 and p_{k-1} . p_2 is previous feature points of p_3' and p_1 is previous points of p_2 . p_3' is calculated by p_1 and p_2 . The speed of p_2 can be concluded by distance and time d-value between p_1 and p_2 . Supposing p_2 and p_3' have the same speed. The product of this speed and interval T is the distance of p_3' . Set p_3' on a straight line that p_1, p_2 are located at. According to the coordinate of p_1 and p_2 , the coordinate of p_3' can be calculated. In the same way, p_2 is still previous feature points of p_4' and p_5' , and they are also calculated by p_1 and p_2 . Differently, the distance of p_4' is the product of speed of the p_2 and twice interval T , the distance of p_5' is the product of speed of the p_2 and triple interval T . The distance between recovery point p_i' and actual point p_i is called d_i and d_i is compared with the error threshold D . If $d_i \geq D$, current point is uploaded as a feature point. If not, current point is discarded as non-feature point. d_3, d_4 in Fig. 1 are smaller than D , so p_3, p_4 are discarded. d_5 is not less than D , so p_5 is uploaded as feature point. The recovery point p_i' of current point p_i is calculated though the previous feature points p_k of p_i and the previous point p_{k-1}' (it can be a feature point or not) of p_k . The speed of p_k is calculated according to p_k and p_{k-1}' . The product of this speed and time d-value between p_i and p_k is the distance of p_i' . Set p_i' in the straight line that p_k, p_{k-1}' are located at. According to the coordinate of p_k, p_{k-1}' and the distance of p_i' , the coordinate of p_i' is calculated. In the recovery phase, p_1, p_2, p_5 and p_k are recovered directly as feature points. p_3, p_4 and p_{k-1} are non-feature points. They are recovered to p_3', p_4', p_{k-1}' according to the above process.

In the recovery phase, the first and second feature points received are recovered directly. Determine whether there are non-feature points between the current p_i and previous feature point p_k from the third feature point. If there are non-feature points, they are recovered in order by calculating corresponding recovery points according to p_k . Then recover the current point p_i after all non-feature points between p_i and p_k are recovered. The process cycles until the recovery of the last feature point.

To deal with the problem of lost point, positioning point p_i introduces lost point count (Count) property and it is given with $p_i = (lng_i, lat_i, t_i, c_i)$. The design idea is to add a counter in the terminal. Positioning data are

collected at an interval. This interval is consistent for counter and data acquisition. When the time reaches an interval, if the signal is acquired, the counter is "0". If the signal is not acquired, that is the signal loss, counter is added with "1" until the signal is acquired. Fig. 2 shows a schematic diagram for the lost point.

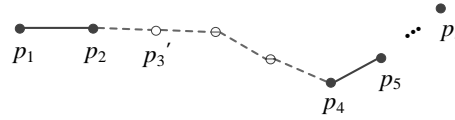


Figure 2: A schematic diagram for the lost point.

As shown in Fig. 2, p_1, p_2 and p_4 are original positioning points. After compression, p_3 is discarded as non-feature point and p_3' is corresponding recovery point of p_3 . There are three intervals between p_3 and p_4 , and it should have two positioning points between them. However, due to signal loss, these two points are not collected. They are called the lost points. When determining whether p_5 is a feature point or not, p_3' and p_4 are made use for calculation direct without considering the lost points. When recovery of p_3' , the lost points are needed to consider. There are four intervals between two feature points p_2 and p_4 . It should have three positioning points. Since $C_4 = 2$, that is to say, two positioning point are lost, so just to recover the only non- feature point p_3 .

2.2 Algorithm description

The recovery point is used to determine whether the current point is a feature point in the compression phase. The recovery point is the non-feature point recovered in the recovery phase. Therefore, the calculation of recovery point is the key of the algorithm. Making use of the previous feature point p_k of p_i' and the previous point p_{k-1}' of p_k to calculate the recovery point p_i' of current point p_i (if $i = 3$, then $p_k = p_2, p_{k-1}' = p_1$).

2.2.1 The compression algorithm

The recovery point of current point is calculated from the third positioning point collected. The actual point has attributes of latitude and longitude. For ease of calculation, latitude and longitude as spherical coordinate can be transformed into rectangular coordinate by the algorithm [17]. That is to say, $p_i = (long_i, lat_i, t_i)$ as spherical coordinate is transformed into $p_i = (x_i, y_i, t_i)$ as rectangular coordinate. For any two points p_i and p_j , the distance of them is $L_{ij} = Dist(p_i, p_j)$ in the trajectory with n points. Accordingly, the distance between p_k and p_{k-1}' is L_k . p_k and p_{k-1}' are the consecutive points and the time d-value of them is $p_k.t - p_{k-1}'.t$ (in the case of signal not loss, the d-value is the interval T). The speed V_i is calculated by Formula (1) and interval T . The distance S_i of p_i' is calculated according to the time d-value of p_i, p_k and Formula (2).

$$L_k = \text{Dist}(p_{k-1}', p_k) = \sqrt{(p_k \cdot x - p_{k-1}' \cdot x)^2 + (p_k \cdot y - p_{k-1}' \cdot y)^2}, \quad 2 \leq k \leq n-1 \quad (1)$$

$$V_i = \frac{L_k}{p_k \cdot t - p_{k-1}' \cdot t} = \frac{\sqrt{(p_k \cdot x - p_{k-1}' \cdot x)^2 + (p_k \cdot y - p_{k-1}' \cdot y)^2}}{p_k \cdot t - p_{k-1}' \cdot t}, \quad 2 \leq k \leq n-1, 3 \leq i \leq n \quad (2)$$

$$S_i = V_i \times (p_i' \cdot t - p_k \cdot t) = \frac{\sqrt{(p_k \cdot x - p_{k-1}' \cdot x)^2 + (p_k \cdot y - p_{k-1}' \cdot y)^2}}{p_k \cdot t - p_{k-1}' \cdot t} \times (p_i' \cdot t - p_k \cdot t), \quad 2 \leq k \leq n-1, 3 \leq i \leq n \quad (3)$$

After calculating the distance of p_i' , position coordinate of p_i' is calculated according to rectangular coordinates of p_k and p_{k-1}' and triangle similar properties [18]. Formulas are as follows. Detailed compression process is shown in Algorithm 1.

$$p_i' \cdot x = p_k \cdot x + \frac{S_i \times (p_k \cdot x - p_{k-1}' \cdot x)}{L_k} = p_k \cdot x + \frac{(p_i' \cdot t - p_k \cdot t) \times (p_k \cdot x - p_{k-1}' \cdot x)}{p_k \cdot t - p_{k-1}' \cdot t}, \quad 2 \leq k \leq n-1, 3 \leq i \leq n \quad (4)$$

$$p_i' \cdot y = p_k \cdot y + \frac{S_i \times (p_k \cdot y - p_{k-1}' \cdot y)}{L_k} = p_k \cdot y + \frac{(p_i' \cdot t - p_k \cdot t) \times (p_k \cdot y - p_{k-1}' \cdot y)}{p_k \cdot t - p_{k-1}' \cdot t}, \quad 2 \leq k \leq n-1, 3 \leq i \leq n \quad (5)$$

Algorithm 1 for compression

Input: p_i, p_k and p_{k-1}', D and T .

Output: A simplified trajectory Traj' with feature points.

1. Collect data points and open counter, $\text{Traj}' = \Phi$;
 2. Upload p_1 and p_2 ; // The first and second positioning point needn't decide and are uploaded directly
 3. $p_k = p_2, p_{k-1}' = p_1$; // p_2 is assigned to p_k, p_1 is assigned to p_{k-1}'
 4. **Foreach** $p_i (i \geq 3)$; // Cyclic judge for p_i
 5. Transform $p_i = (\text{lng}_i, \text{lat}_i, t_i)$ to $p_i = (x_i, y_i, t_i)$; // Spherical coordinate is transformed into rectangular coordinate
 6. Calculate S_i ; // Calculate the distance of p_i'
 7. Calculate (x_i, y_i) ; // Calculate the rectangular coordinate of p_i'
 8. Transform $p_i = (x_i, y_i, t_i)$ to $p_i = (\text{lng}_i, \text{lat}_i, t_i)$; // Rectangular coordinate is transformed into spherical coordinate
 9. $\text{Dist}(p_i, p_i')$ is d_i ; // The distance of p_i and p_i' is d_i
 10. Compare d_i and D ; // Error threshold is D
 11. If $(d_i \geq D)$, upload p_i ; // If $d_i \geq D$, upload p_i as a feature point
 12. $p_k = p_i, p_{k-1}' = p_{i-1}'$; // p_i assigned to p_k, p_{i-1}' assigned to p_{k-1}'
 13. Else $(d_i < D)$, ignore p_i ; // If $d_i < D$, discard p_i as a non-feature point
 14. **End** foreach; // End of cycle
 15. **Return** $\text{Traj}' = \{p_1, p_2, \dots, p_k, \dots, p_n\}$
-

2.2.2 The recovery algorithm

Determine whether exist the non-feature points between the current point p_i and the previous feature point p_k from the third feature point received. Judgment is that getting the number N_i of intervals based on the time d-

value of two points divided by the interval T . By the Formula (6) and the number C_i of lost points p_i , the number M_i of recovery point is calculated. Special attention is that the interval number of two adjacent original positioning points is “1”, but there is no recovery point between them. Therefore, the number of

recovery points should extra minus “1”. If M_i is not equal “0”, it means that it exists recovery points. To recover the M_i recovery points in order. The speed of the recovery point is calculated by Formula (2), and the product of speed and r interval T is the distance G_r of the r -th recovery point.

$$N_i = \frac{p_i.t - p_{k-1}.t}{T}, \quad 3 \leq i \leq n, 2 \leq k \leq n-1 \quad (6)$$

$$M_i = N_i - C_i - 1, \quad 3 \leq i \leq n \quad (7)$$

$$G_r = V_i \times r \times T, \quad 3 \leq i \leq n, 1 \leq r \leq M_i \quad (8)$$

After calculating the distance of each recovery point, the position coordinate of each recovery point is calculated according to rectangular coordinate of p_k and p_{k-1} , triangle similar properties and Formula (4), (5). Detailed recovery process shown in Algorithm 2.

Algorithm 2 for recovery

Input: Feature points and T .

Output: A recovered trajectory $Traj$ with feature points and recovery points.

1. Receive feature points and $Traj = \Phi$;
 2. Recover p_1 and $p_2, Traj = \{p_1, p_2\}$; // The first and second feature points are recovered directly without deciding
 3. $p_k = p_2, p_{k-1}' = p_1$; // p_2 is assigned to p_k, p_1 is assigned to p_{k-1}'
 4. **Foreach** p_i ($i \geq 3$); // Cyclic judge for current feature point p_i
 5. Calculate M_i ; // Calculate the number of recovery points between current feature point and previous feature point
 6. **Foreach** r ($1 \leq r \leq M_i$); // Cycle begins from 0 to M_i non-feature points
 7. Transform $p_i = (lng_i, lat_i, t_i)$ to $p_i = (x_i, y_i, t_i)$; // Spherical coordinate is transformed into rectangular coordinate
 8. Calculate G_r ; // Calculate the distance G_r of current recovery point
 9. Calculate (x_i, y_i) ; // Calculate the rectangular coordinate of current recovery point
 10. Transform $p_i = (x_i, y_i, t_i)$ to $p_i = (lng_i, lat_i, t_i)$; // Rectangular coordinate is transformed into spherical coordinate
 11. Recover recovery points; // Recover recovery points
 12. Recover p_i ; // Recover current feature point p_i
 13. $p_k = p_i, p_{k-1}' = p_{i-1}'$; // p_i is assigned to p_k, p_{i-1}' is assigned to p_{k-1}'
 14. **End** foreach; // End of the cycle
 15. **Return** $Traj = \{p_1, p_2, \dots, p_n\}$;
-

Compression algorithms can be divided into lossless and lossy compression. Lossless compression enables exact reconstruction of the original data with no information loss. In contrast, lossy compression introduces inaccuracies when compared to the original data. Lossy compression allows the compression process to lose some information. Although we cannot fully recover the original data, but the lost part has a smaller impact on the understanding of the original data, at the same time, in exchange for a smaller compression rate [19]. The primary advantage of lossy compression is that it can often reduce the storage requirements drastically while maintaining an acceptable degree of error [20]. Although all compressed data are recovered by the algorithm proposed in this paper, but it has a certain geographical deviation, so that this algorithm is lossy compression.

3 Experiments

To verify the applicability and performance of the algorithm, a large number of experiments are performed about original data acquisition, data compression and data recovery real-time by *PC* and *GPS* phones.

3.1 Experimental environment

The existing four global satellite navigation system in the world, namely the U.S. GPS system, China Beidou system, the European Galileo system and Russia GLONASS system [21]. GPS system is widely used because of its wide coverage, high positioning accuracy, short positioning time and small location-dependent and

other advantages. Positioning data are collected real-time with Android operating system and GPS positioning system in the experiment. Android includes API libraries that simplify the development related to the device hardware. Android SDK includes location-based services, and determines the current location by GPS.

The mobile phone is used as terminal in the experiment, which is regarded as a GPS receiver and a compression processor for positioning data. The PC is used as server, which is used for receiving positioning data compressed, and recovering the original trajectory based on those data.

3.2 Select the experimental route

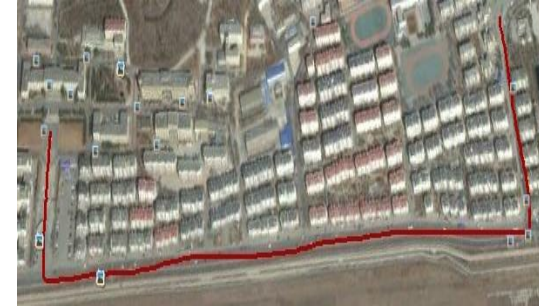
The actual movement broadly divided into walk, non-walk (car, bicycle, aircraft, ships, etc.) and mixed mode (alternating walk and non-walk) according to different travel modes. According to different speed, it can be broadly divided into 0-30 *km/h* as the low-speed movement (walking, jogging, bicycle, etc.), 30-60 *km/h* as the middle-speed movement (low speed vehicles, etc.) and 60 *km* above as high-speed movement (cars, boats, airplanes of high speed, etc.). Assuming the original trajectory with n positioning points, the purpose of the experiment is to select as few as m feature points. When $m < n$, compression trajectory is constituted with m feature points. Set $r = m / n$ is the compression rate, the r is the smaller the better without changing the original shape of the trajectory of geography. For moving at different speed and different travel modes, it should set a different error threshold. In this paper, the

experiment is given priority to low speed movement, and divided into walk, non-walk and mixed mode for validation. Data is acquired at 2s intervals, 5s intervals, 10s intervals and 20s intervals. For each acquisition interval, 5m, 10m, 15m, 20m and 25m as the error threshold are set for compression.

In this experiment, the actual routes as an example are shown in Fig. 3. Positioning data acquisition,



a) The route of non-walk (by bus) and mixed mode (by bus and walk)



b) The route of walk

Figure 3: A schematic diagram for actual routes.

3.3 Experimental results and analysis

3.3.1 Effects of different parameters on the compression rate

In the actual routes shown in Fig. 3, the compression rate is impacted by the acquisition interval, the error threshold and the travel mode.

Under the conditions of the error threshold are 5m, 10m, 15m, 20m and 25m, and the travel mode is walk, the effect of different acquisition intervals on compression rate is shown in Fig. 4.

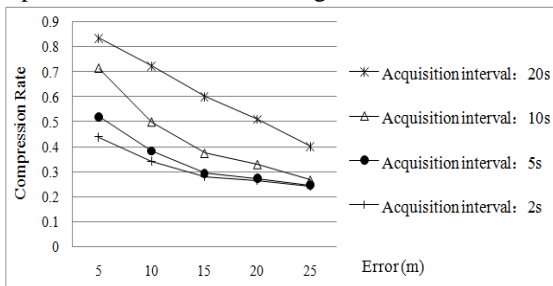


Figure 4: Compression rate of different acquisition intervals.

The Fig. 4 shows that, for the walk of low-speed movement, the shorter the acquisition interval is, the more positioning data are compressed and the smaller the compression rate is. At the same time, we can draw that data compression rate decreases with increasing error threshold. That is to say, the bigger threshold is set, the more data are discarded and the smaller the compression rate is. With the increasing of the threshold, it also brings the risk of losing detailed information.

compression and recovery are executed real-timely. Fig. 3a) shows a route of non-walk (by bus) and mixed mode (by bus and walk); Fig. 3b) shows a route of walk. Due to traffic restrictions, travel by bus is slow. So this experiment is under the condition of low-speed movement.

Under the conditions of the error threshold are 5m, 10m, 15m, 20m and 25m, and the acquisition interval is 10s, the effect of different travel modes on compression rate is shown in Fig. 5.

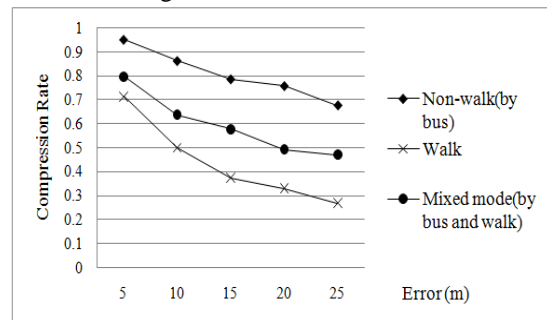


Figure 5: Compression rate of different travel modes

The Fig. 5 shows that for low-speed movement, walk on the relatively straight route without more detours and its speed is more even, so it has the minimum compression rate at the same error threshold. Non-walk is on the route with more detours and it is ongoing to stop and go, at the same time, the change degree of speed is bigger, so it has the maximum compression rate at the same error threshold. Mixed mode includes walk and non-walk, so the compression rate ranges between them.

3.3.2 Effectiveness

The recovery trajectory is compared with the original trajectory to verify the effectiveness of proposed algorithm. The recovery trajectory approximate the original trajectory can be obtained in the case that error threshold is set appropriately, as shown in Fig. 6.

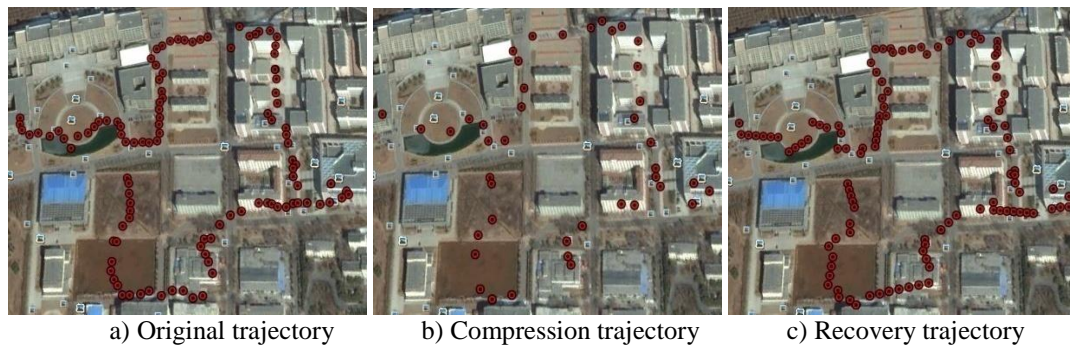


Figure 6: A schematic diagram for original trajectory, compression trajectory and recovery trajectory.

The Fig. 6 shows a schematic diagram for original trajectory, compression trajectory and recovery trajectory of walk under the conditions of acquisition interval is 10s and the error threshold is 10m. Fig. 6a) shows the original trajectory with 112 points; Fig. 6b) shows the compressed trajectory according to the online compression algorithm for positioning data acquisition with 42 points; Fig. 6c) shows the recovery trajectory by recovery algorithm with 112 points, the same number as the original data, recovery trajectory approximates original trajectory. That is to say, the compression rate is 37.5%, and denser data are discarded. In addition, the spatial error of points recovered is strictly controlled under the error threshold. The above fact shows that the proposed algorithm is effective in practical applications. The deviation of a recovery trajectory depends on the error threshold predetermined. The larger error threshold is set, the more non-feature points are compressed, the compression rate is smaller, but the deviation between original data and recovered data is larger. Conversely, the smaller error threshold is set, the less non-feature points are compressed, the compression rate is larger, but the deviation between original data and recovered data is smaller, the recovered data are more approximate to the original data.

4 Conclusion

In this paper, an online compression algorithm for positioning data acquisition is proposed based on a straight line approach. Considering the change of speed and direction, the error threshold between the actual point and recovery point is set, as the required accuracy of user, to replace the threshold of speed or direction. As a result, the feature information loss and trajectory error can be significantly reduced. The algorithm is suit for different road conditions and travel modes, so it has a better adaptability than the existing compression algorithm. In the future, one possible approach for improving the compression of positioning data would be to use knowledge of the road network. This approach would require fast detection of deviations from the road network. A key goal in this approach is that enable a smaller compressed representation with low calculating overhead and reduced error.

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