CHAPTER 4

COMPARISON OF DIGITIZED MAP AND BASE MAP – ANALYSIS AND RESULTS

4.1 Introduction

This chapter examines the consistency between the base map and the digitized route map, the map with the link-node representation. The objective is to assess the accuracy of the digitized map in representing a route and how this accuracy is related to the choice of link length. This is an important issue, since, as we will see later, the choice of link length will alter the total length of the route. If the digitized map were utilized for travel time estimation, the choice of link length would definitely affect the accuracy of the prediction.

Various measures could be used to quantify the discrepancy between the base map and the digitized map. One of the measures considered in the study is the minimum distance of each data point obtained from different trips to the links in the digitized map. Ideally, each data point should fall right on one of the links if the match is perfect. The farther the points are from the digitized route the lesser is the accuracy. It is expected that the discrepancy should increase as the length of the link increases.

The results of this research can be utilized to choose the optimum digitizing interval or link length. Longer digitizing intervals would result in an efficient use of resources such as less memory requirement and faster processing time. It may be, however, undesirable for certain accuracy requirement. In practice, one often has to seek a balance between accuracy and efficiency.

4.2 Description of base map and digitized map

Table 4.1 gives the details of base maps obtained from four trial trips named 1, 2, 3, 4. The details include the number of GPS data points on the maps, the distances of routes obtained from the maps and average distance between points and the time taken to complete the trip.

Table 4.1: Details of base maps

Trip Details from Original Map	1	2	3	4
Number of GPS data points in Original Map	734	521	489	426
Distance of route in base map (meters)	8047	8001	8074	8035
Average distance between successive points	11	15.4	16.5	18.7
Time taken to complete trip (seconds)	734	521	489	426

The first row shows the number of GPS data points collected in each trip. It is inversely proportional to the speed of the vehicle. The higher the number of data points, the slower the average speed of the vehicle. The second row gives the distance of the route calculated using the base map, which is the sum of the distances between every two consecutive points along the route. The third row gives the average distance between two consecutive data points in the GPS data file. This is also increasingly proportional to the average speed of the vehicle. The fourth row gives the time taken to complete the trip and is equal to the number of data points in the file since data are collected every second.

Table 4.2 shows the details of the digitized route maps, digitized to 10m intervals. The length of the trip is shorter in the digitized map when compared with the base maps. The number of nodes in each of the digitized maps is very close though the number of data points in the base map differs by a large value.

Table 4.2: Details of digitized route map

Trip Details from Digitized Route Map	1	2	3	4
Number of GPS data points in Digitized Map	801	799	806	800
Distance of route in Digitized map (meters)	7998	7998	8040	7993
Average distance between successive points (meters)	10	10	10	10

4.3 Comparison of base map and digitized map

The total distance of a route on the digitized route map decreases as the digitizing interval increases as shown in Table 4.3.

Table 4.3: Distance Comparison

Digitized Route Map Distance for 10m Intervals				
	1	**2**	**3**	**4**
Base map Distance	8042	7997	8070	8030
Digitized Route Map Distance	7992	7975	8033	7990
Ratio	**0.993**	**0.997**	**0.995**	**0.995**
Digitized Route Map Distance for 30m Intervals				
	1	**2**	**3**	**4**
Base map Distance	8042	7997	8070	8030
Digitized Route Map Distance	7978	7964	8013	7958
Ratio	**0.992**	**0.995**	**0.992**	**0.991**
Digitized Route Map Distance for 50m Intervals				
	1	**2**	**3**	**4**
Base map Distance	8042	7997	8070	8030
Digitized Route Map Distance	7962	7953	7970	7958
Ratio	**0.990**	**0.994**	**0.987**	**0.991**
Digitized Route Map Distance for 70m Intervals				
	1	**2**	**3**	**4**
Original Distance	8042	7997	8070	8030
Digitized Route Map Distance	7930	7926	7948	7934
Ratio	**0.986**	**0.991**	**0.984**	**0.988**

As expected, the ratio of the distance of the route obtained from the digitized route map and the distance of the route obtained from the base route map decreases as the distance interval increases. This shows that the accuracy of the digitized map decreases as the interval of digitizing is increased. However, when the link length increases from 10m to 70m, the ratio is only decreased by less than 1%.

4.4 Accuracy of digitizing route maps

The Matlab code developed can digitize the map to any desired interval of distance. The accuracy of the digitized map for different intervals as compared with the base map and other plots of the same route need to be addressed.

4.4.1 Distance of point from digitized map

The distance from every point on a base map to the closest link on the digitized route map is calculated. Figure 4.1 shows the GPS data points and the nodes and links in the digitized route map points.

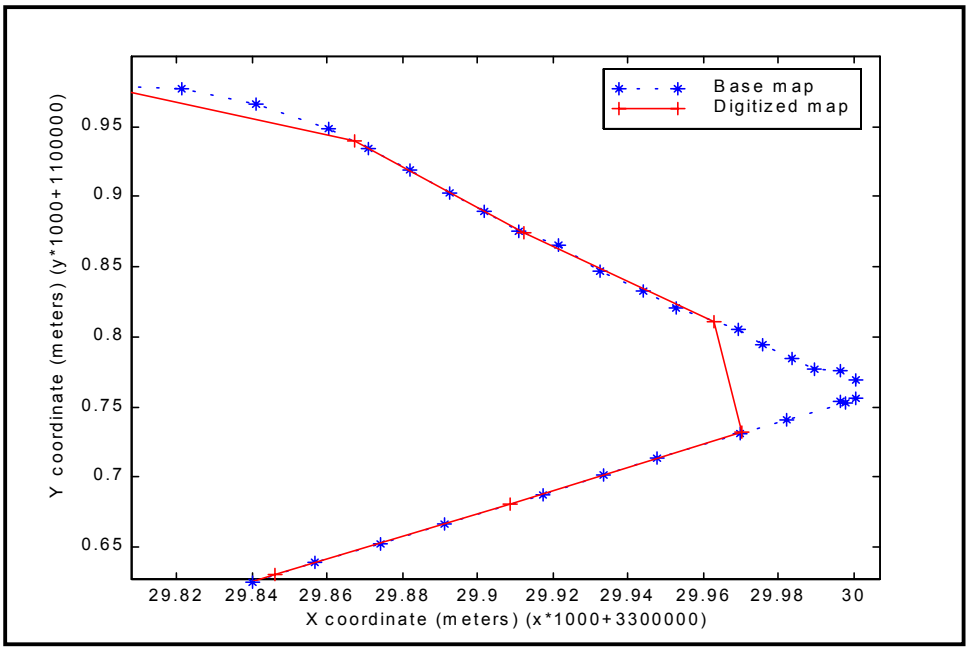

Figure 4.1: Digitized Map vs. Base Map

The average minimum distance provides an idea of how accurately the digitized route map represents the base map. If the average minimum distance value is consistent and small for all the maps then we can take the digitized map obtained from any one base GPS data file for one

trip to be representative of the route itself. In Figure 4.2, **P(1), P(2), P(3), P(4), P(5)** represent points on the base map and **Q(1), Q(2), Q(3), Q(4), Q(5)** represent nodes on the digitized map.

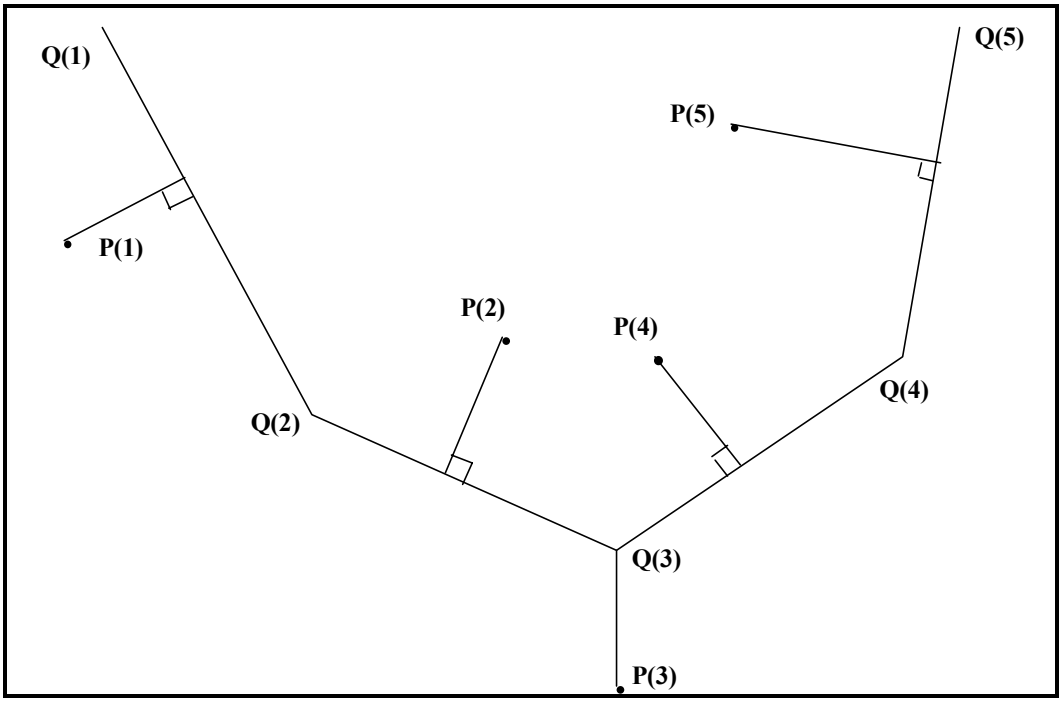

Figure 4.2: Illustration for perpendicular distance calculation

The algorithm for finding out the minimum distance is as follows.

Step 1: Initialization:

Label the point in the base map as **P(i)**, i=1, 2, 3….N_1

Label the nodes in the digitized map as **Q(j)**, j=1, 2, 3….N_2

Where **P** and **Q** refer to the point

Step 2: Set i = 1

Step 3: j=1; N={}

N= D (**P(i)**,**Q(j)**) (Euclidian Distance between two points)

N =(N, n) (Compute distance between **P(i)** and **Q(j))**

If j not equal to N_2

Next j

Else go to Step 4

Step 4**:** M=Min (N) (Finds Minimum value in array N)

G = Getline (**Q(j)**, **Q(j-1)**, **Q(j+1)**) (Finds the line segment closest to the point)

Step 5: d=(**P(i)**, G) (Computes the minimum distance from the point to the line segment.

A={A,d}

If i not equal to N_1

Next i,

Return to Step 3

Else

Stop

The output of the algorithm yields the minimum distance of each point on the base map from the link on the digitized route map. The algorithm was coded in Matlab. The base maps obtained from the points in the four test files were digitized into intervals of 10, 30, 50, 70 meters. Each base map yielded 4 digitized maps. The four base maps were compared with each of the 16 digitized maps. The average minimum distance of a point in a base map to a link on the digitized map is shown in Table 4.4. A plot of the average minimum distance obtained for each interval in each comparison is shown in Figure 4.3. The plot shows the average minimum distance is consistent for all the intervals. The variance and standard deviation results of the comparison between the four base maps and the route map produced by digitizing the base map obtained from the GPS data in trial 1 are shown in Table 4.5.

Table 4.4: Average minimum distance for different digitizing intervals

Serial No.	Comparison of trials Digitized VS Base Map	Digitizing Intervals in meters			
		10	30	50	70
1	1 VS 1	2.35	4.76	7.37	9.51
2	1 VS 2	2.46	5.28	7.37	9.23
3	1 VS 3	2.38	4.74	7.34	9.32
4	1 VS 4	2.42	4.89	7.26	9.57
5	2 VS 1	2.68	4.98	7.20	10.06
6	2 VS 2	2.65	5.10	7.44	10.33
7	2 VS 3	2.58	5.40	6.90	10.16
8	2 VS 4	2.32	4.79	6.93	10.33
9	3 VS 1	2.53	4.96	6.99	9.27
10	3 VS 2	2.57	4.99	7.16	9.98
11	3 VS 3	2.51	4.91	7.10	10.03
12	3 VS 4	2.61	5.01	7.23	10.14
13	4 VS 1	2.55	4.96	6.99	9.27
14	4 VS 2	2.52	5.00	7.10	10.10
15	4 VS 3	2.48	4.94	7.15	10.11
16	4 VS 4	2.41	5.05	7.27	10.2

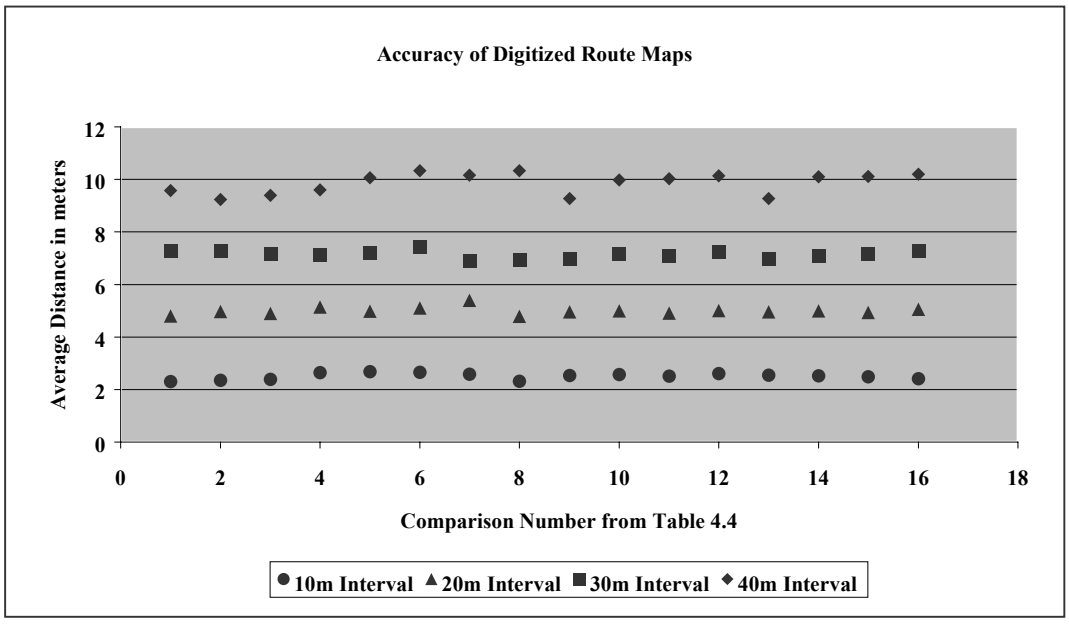

Figure 4.3: Plot of average minimum distance of point to digitized route map

Table 4.5: Comparison of results: Digitizing at different intervals

Map Digitizing Results- Base Data VS Digitized Data				
Comparison of Intervals				
	1VS 1			
Digitizing Interval	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	799.00	400.00	267.00	200.00
Average distance (m)	2.35	4.76	7.37	9.51
Variance	2.10	9.16	19.44	35.29
Standard Deviation	1.45	3.03	4.41	5.94
	1 VS 2			
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	799.00	400.00	267.00	200.00
Average distance (m)	2.46	5.28	7.37	9.23
Variance	2.45	8.72	19.15	31.90
Standard Deviation	1.57	2.95	4.38	5.65
	1 VS 3			
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	799.00	400.00	267.00	200.00
Average distance (m)	2.38	4.74	7.34	9.32
Variance	2.15	8.72	17.26	36.10
Standard Deviation	1.46	2.95	4.15	6.01
	1 VS 4			
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	799.00	400.00	267.00	200.00
Average distance (m)	2.42	4.89	7.27	9.57
Variance	1.89	7.96	17.63	35.43
Standard Deviation	1.37	2.82	4.20	5.95

The variance increases with the interval. This shows that as the route digitizing interval increases the accuracy of the route map decreases. The required digitizing interval however, depends on the application. Total distance of the route also changes when the route map is digitized.

4.4.2 Comparison with alternate route

An alternate route was chosen to further validate the procedure and four trips were made to collect GPS vehicle location data. The trial trip data were called 5, 6, 7, 8 and the digitized route map was created using GPS data from trial 5. The minimum distance of each data point from the digitized route map is calculated. The mean and the variance are shown in Table 4.6.

Table 4.6: Alternate route map comparison results.

Validation with Alternate route map				
	5 VS 1			
Digitizing Interval	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	251.00	126.00	84.00	63.00
Average distance (m)	2.45	4.76	7.31	9.54
Variance	2.13	8.82	19.90	35.83
Standard Deviation	1.46	2.97	4.46	5.99
	5 VS 2			
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	251.00	126.00	84.00	63.00
Average distance (m)	2.37	4.84	7.20	9.22
Variance	2.45	9.85	19.80	36.16
Standard Deviation	1.57	3.14	4.45	6.01
	5 VS 3			
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	251.00	126.00	84.00	63.00
Average distance (m)	2.24	4.67	7.05	9.32
Variance	2.31	8.92	18.07	36.44
Standard Deviation	1.52	2.99	4.25	6.04
	5 VS 4			
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	251.00	126.00	84.00	63.00
Average distance (m)	2.32	4.64	7.02	9.36
Variance	2.01	8.80	17.91	36.43
Standard Deviation	1.42	2.97	4.23	6.04

4.4.3 GPS data collected at different interval

The GPS data used so far was collected at intervals of one second. Trial 9 was made along Tom's Creek A route to collect GPS data at intervals of 5 seconds. The base map was digitized into intervals of 10, 30, 50, 70 meters and compared with the one-second data file obtained earlier. The Table 4.7 shows the results of the comparison.

Table 4.7: Accuracy of digitized map obtained from GPS data interval

Comparison for different intervals of Data collection				
	10 VS 1			
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	799.00	400.00	267.00	200.00
Average distance (m)	2.56	5.16	7.44	9.99
Variance	2.11	8.67	18.23	32.25
Standard Deviation	1.45	2.94	4.27	5.68

The results, which are similar to those in table 4.6, indicate that the interval of data collection does not affect the digitized route map. The average distance and variance values are in the same range.

4.4.4 Comparison of Road Centerline map with digitized route map

Figure 4.4 shows a Road Centerline map and a digitized route map imported in AutoCAD. It can be seen that the data points on the digitized route map lie close to Road Centerline showing a good fit. Figure 4.5 is a section of the plot clearing showing the data points.

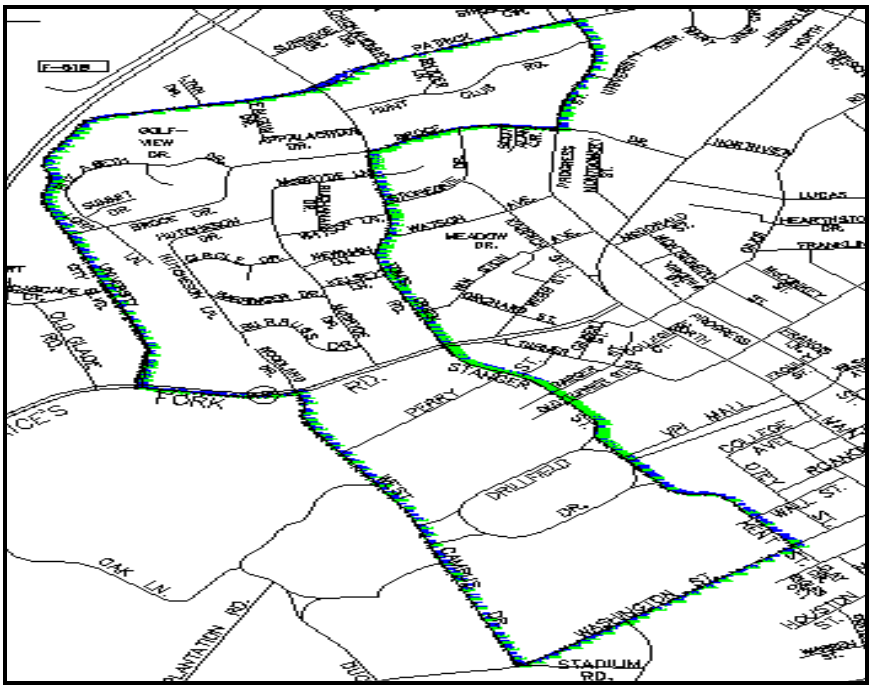

Figure 4.4: Road Centerline map and digitized route map

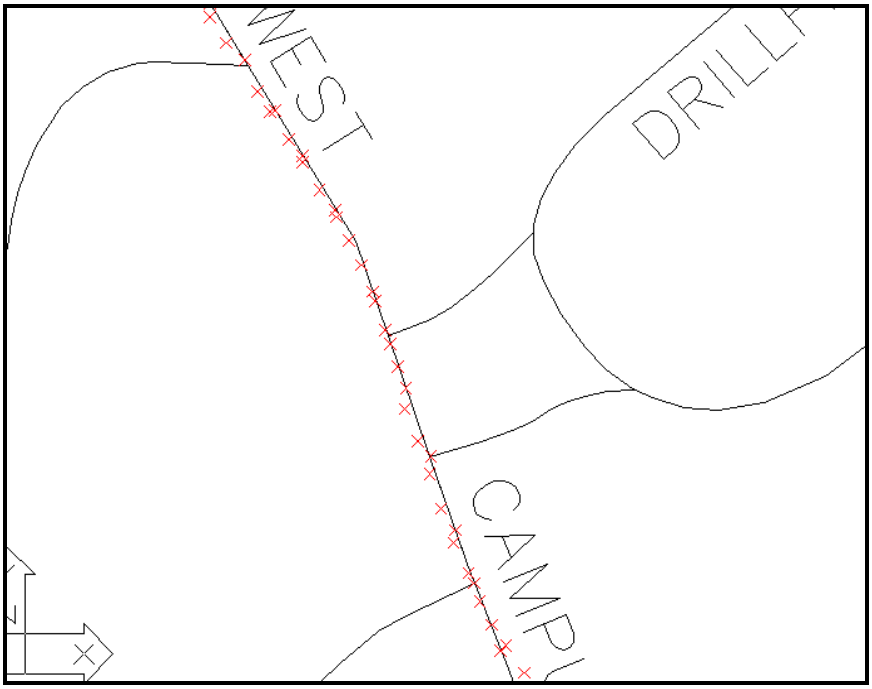

Figure 4.5: Section of digitized route map and Road Centerline map

The points on the Tom's Creek A bus route in the Road Centerline map were obtained by manually clicking on the links and stored. The average minimum distance of the points from the digitized map obtained was calculated. The results of the comparison are shown in Table 4.8. The comparison shows similar values of average minimum distance. This implies that the base maps obtained using the GPS data are close in accuracy to the Road Centerline maps.

Table 4.8: Comparison between digitized map and Road Centerline map

Comparison between Road Center Line points and Digitized map				
Digitizing Interval in meters	**10.00**	**30.00**	**50.00**	**70.00**
Number Of Points	799.00	400.00	267.00	200.00
Average distance (m)	2.57	4.87	7.54	10.15
Variance	2.31	8.31	19.56	34.49
Standard Deviation	1.52	2.88	4.42	5.87