Probe Data Analysis for Road Slope

—

Shengjie Xue, Xinyi Chen, Liangji Wang, Xuan Ding

Overview

Our method contains following steps:

1. Load and process the link data
2. For each link, find all the matched probe points
3. Derive road slope of each link
4. Compare the derived road slope with the surveyed road slope

Load Links

1. In each line of link data given, there are several nodes (consist latitude longitude and elevation) in "shapeInfo" (row 15). We build a partial link between each two adjacent nodes and put all links into a list. (A link list may contains several partial links with the same "Linkid")
2. For each line in LinkData file, repeat step 1.
3. Then we get a group of link lists and finish loading all the information of links.

Match Links with Probe Points

1. We decide to find the link for a probe point by calculating the smallest distance between the point and the all the partial links which have been created before.
2. Because points with the same "Sample ID" were collected closely, we can assume that they will be assigned with partial links within the same link list.
3. Thus we can simplify the process by finding the link list of the points with the same "Sample ID" first, and then find partial links for each point individually.

Match Links with Probe Points
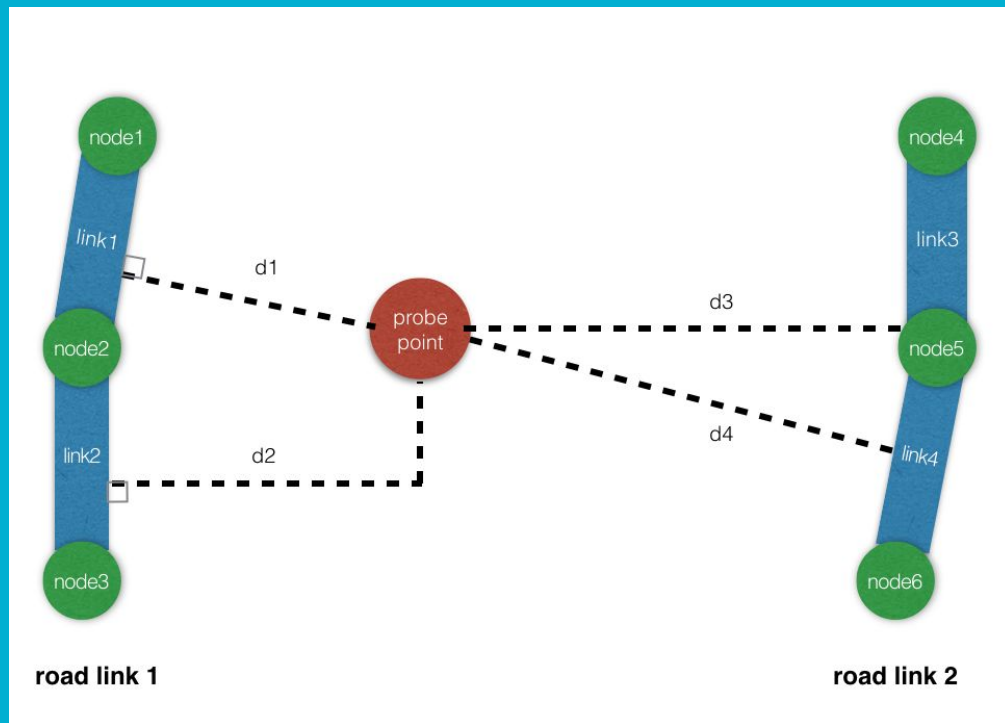
1. Calculate the distance between probes and links

2. If d2<d1<d3<d4, then the probe point should be matched to link2 in road link1

Compute slopes and evaluation

1. Read all the mapping data derived from first step
2. Since one link can be matched by many porbe points, store probe points by link id.
3. We can derive a slope using two probe points, for each link, there are many matched probe points, so we can derive many slopes(using each two probe points).
4. Calculate the average of derived slopes for each link, evaluate average slope with the surveyed road slope. If the difference between them is greater than 2 degrees, consider the derived road slope is wrong.
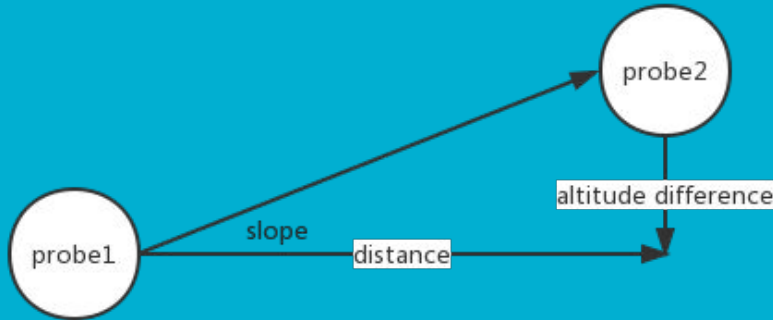
Compute slopes and evaluation
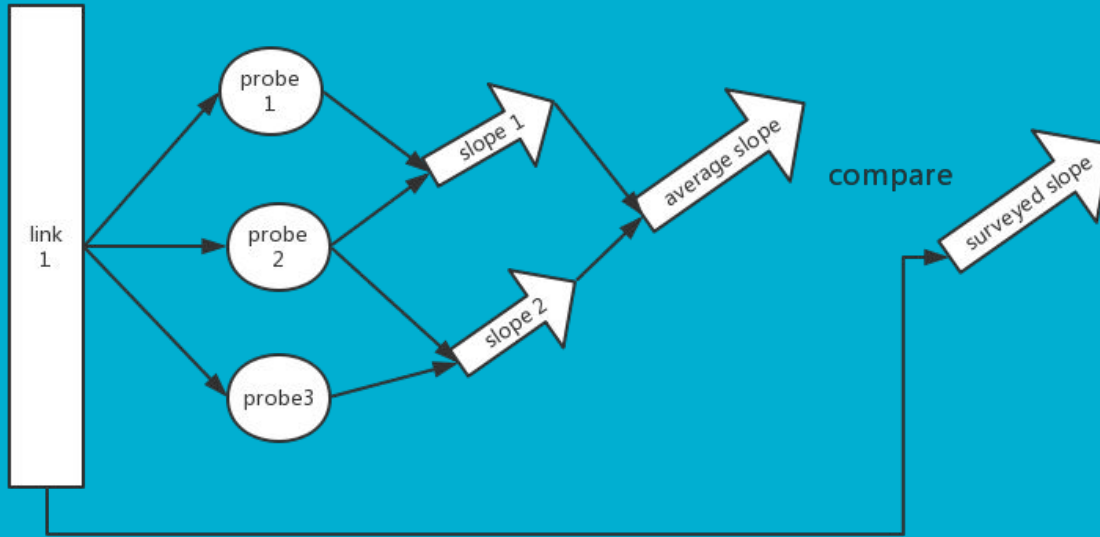
1. 3 probes are mapped to link1
2. Derive 2 slopes using each two of probes
3. Compute the average slope
4. Evaluate average slope with surveyed slope

Derive slope using two probe points

—

1. Compute the distance between two probes using their longitudes, latitudes and earth radius.
2. Slope = math.atan(distance / altitude difference)

Result & Analysis:

1. MatchedPoints Record :

sampl-eID	dateT-ime	sourc-eCode	latitud-e	longit-ude	altitud-e	speed	headi-ng	linkP-VID	directi-on	distFr-omRef	distFr-omLink

```
3496, 6/12/2009 6:12:49 AM, 13, 51.496868217364, 9.38602223061025, 200, 23, 339, 62007637, F ,7.35792003289, 39.5009431402
3496, 6/12/2009 6:12:54 AM, 13, 51.4966822229326, 9.38615726307034, 200, 10, 129, 62007637, T ,2.50711685404, 13.9440617111
3496, 6/12/2009 6:12:59 AM, 13, 51.4967048540711, 9.38642229884863, 201, 21, 60, 567329767, T ,8.75931203938, 25.5036311479
3496, 6/12/2009 6:13:04 AM, 13, 51.4967492781579, 9.38683996908367, 201, 0, 360, 567329767, T ,15.8887116439, 70.3995955971
3496, 6/12/2009 6:13:09 AM, 13, 51.4968639425933, 9.38729401677847, 199, 0, 360, 567329767, T ,67.7620114705, 122.46433518
3496, 6/12/2009 6:13:15 AM, 13, 51.4969302434474, 9.388771596178412, 198, 5, 89, 567329767, F ,115.006095567, 169.769932659
3496, 6/12/2009 6:13:20 AM, 13, 51.4969574846327, 9.38779382966459, 198, 1, 288, 567329767, F ,124.13499404, 178.895001226
3496, 6/12/2009 6:13:25 AM, 13, 51.4969521202147, 9.3878052290529, 197, 0, 310, 567329767, T ,125.225735847, 179.98935203
3496, 6/12/2009 6:13:30 AM, 13, 51.4969490189105, 9.38781813718379, 196, 0, 274, 567329767, T ,126.543081612, 181.308171791
3496, 6/12/2009 6:13:35 AM, 13, 51.4969443250448, 9.38784018158913, 196, 0, 226, 567329767, F ,128.815496522, 183.580754028
3496, 6/12/2009 6:13:40 AM, 13, 51.4969411399215, 9.3878517486155, 197, 0, 201, 567329767, F ,129.994022012, 184.758157932
3496, 6/12/2009 6:13:46 AM, 13, 51.4969385415316, 9.3878554366529, 197, 0, 182, 567329767, F ,130.332964613, 185.096019433
3496, 6/12/2009 6:13:51 AM, 13, 51.4969374518842, 9.38785669393837, 197, 0, 232, 567329767, F ,130.443968147, 185.206503726
3496, 6/12/2009 6:13:57 AM, 13, 51.4969362784177, 9.38785945996642, 197, 0, 202, 567329767, F ,130.717217223, 185.479003785
3496, 6/12/2009 6:14:03 AM, 13, 51.4969357755035, 9.38786029815674, 197, 0, 199, 567329767, T ,130.796650688, 185.558126239
3496, 6/12/2009 6:14:08 AM, 13, 51.496934518218, 9.38786323182285, 197, 0, 179, 567329767, T ,131.086590737, 185.847143818
3496, 6/12/2009 6:14:13 AM, 13, 51.4969339314848, 9.38786532729864, 197, 0, 184, 567329767, F ,131.301036028, 186.06104385
3496, 6/12/2009 6:14:19 AM, 13, 51.4969324227422, 9.38786742277443, 197, 0, 199, 567329767, T ,131.494512869, 186.253414872
3496, 6/12/2009 6:14:25 AM, 13, 51.496931836009, 9.38786884769797, 197, 0, 178, 567329767, T ,131.636244618, 186.394610914
3496, 6/12/2009 6:14:31 AM, 13, 51.4969309978187, 9.38786951825023, 197, 0, 183, 567329767, F ,131.690228512, 186.447980346
```

Result & Analysis:

- Number of tested probe points: 24019
- Number of abnormal road slopes: 3417
- Error rate: 14.226 %
- Average error: 1.019 °
- Range of derived slope: -29.627 ° to 24.589 °

Explanation

- Number of tested probe points: Number of probe points we use
- Number of abnormal road slopes: If the difference between them is greater than 2 degrees, consider the derived road slope is wrong.
- Error rate: Number of error / number of probe points we use
- Average error: Add up all differences between derived slope and surveyed slope/ number of tested probe points
- Range of derived slope: Max value and min value of derived slopes

Result & Analysis:

Error analysis:

1) Measuring error
   Although the measuring equipment has high accuracy, some measuring error exists.
2) Random error
   There are not enough probes points and nodes in road link data.
3) A small number of probe points may be matched to a wrong link due to our incomplete algorithm.