Microsegmenting

An approach for precise distance calculation for GPS based ITS applications

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Outline

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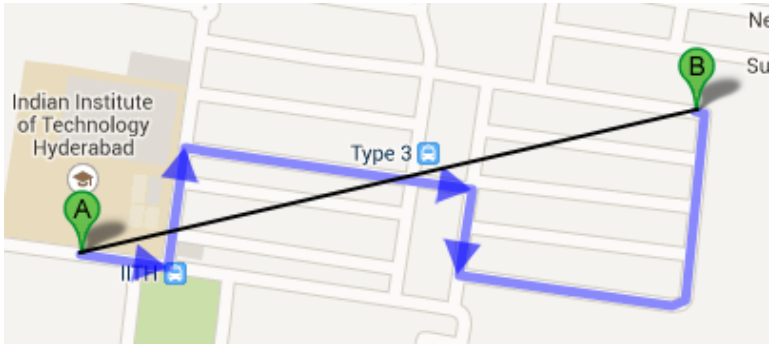
Introduction

- Rapid growth in the wireless communication and positioning technology in recent past.
- Development of the field of Intelligent Traffic Systems (ITSs') and many parallel fields of study.
- The core of any ITS and relating field of study is the distance calculation.
- GPS data is the general source of these calculations.
- The currently used method of onroad distance calculation in ITSs' gives rise to **"Displacement Effect".**

Displacement effect



- Distance between two geographical points without considering geographical information may cause underestimation of the onroad distance.
- Theoretically the error in calculation would depend on
  - Frequency of GPS traces i.e. the length of road between two GPS traces.
  - The curvature or the number of turns between the road segment between points of interest.
- It's easy to overlook !

AIM

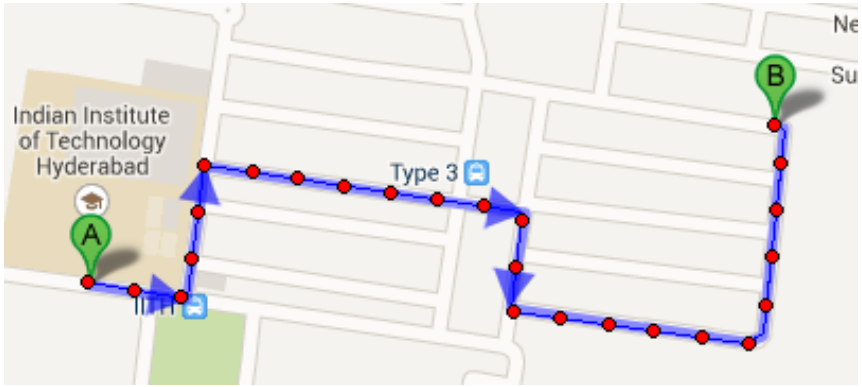
- To develop a methodology for onroad distance calculation considering the geographic structure of the route.
- A methodology in which the precision of the distance calculation can be controlled.
- None of the presently used methods gives the control as the point of interest are fixed by the data set used.
- So formally : -

  “Given a route and a repository of real-time or historical GPS traces, of a vehicle on the given route we aimed to develop a methodology that accurately calculates the distance travelled by the vehicle between any two traces using the simple and novel approach of ***microsegmenting****.”*

Microsegmenting : proposed approach

- The overall idea utilizes the fact that in all the ITSs' as well as relating studies the route is known in advance.
- The idea was to
  - divide the route of interest in segments of desired length and
  - compute the distance between the points of interest by matching the points to the segments.
- We face the following three problems :
  1. How to segment the route of interest?
  2. How to match the data points to the segments?
  3. Finally, how to calculate the distance?

Module 1 : Microsegmenting Module

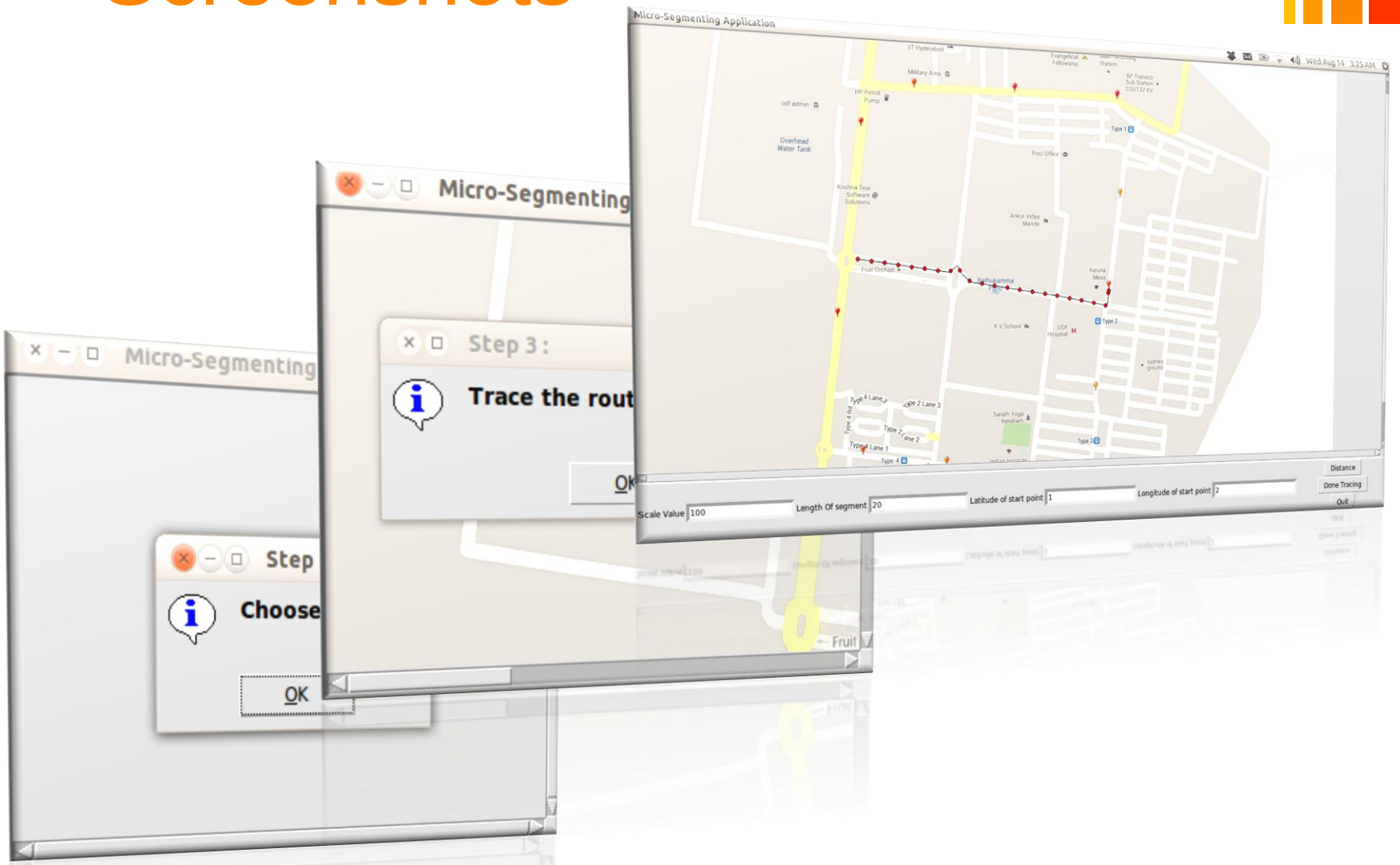


- In this module the route of interest is segmented in segments of equal length.
- This module is a preparatory module and has to be performed only once before the actual process.
- For the execution of this module a Microsegmenting application, Microsegmentor, was developed.

Microsegmentor

- This Application had three major components :
  - **The first part was aimed at defining the physical entity route, mathematically**
    - This was achieved by approximating the route by a polyline
  - **The aim of the second part was to get segments of equal length on the polyline**
    - This was achieved by dividing a line-segment into equal parts by finding equidistant points on it.
  - **The last part of the application was to convert the canvas coordinates to GPS coordinates**

Screenshots



Module 2 : Map Matching module

- Many map matching algorithms available.
- Choice of algorithm is important as it's the only major overhead.
- For validation purpose we chose the most basic $O(n^2)$ algorithm to phase out any possibility of mistake.
- The algorithm searches for the best matching road segment by comparing with all the segments of the route.
- At the end of this module each data point is associated with a segment ID i.e. the serial number of the segment.

Module 3 : Calculation Module

- The onroad distance covered by the vehicle is then calculated in this module by the following formula :

$$D_i = [(l_i - l_{i-1}) \times l]$$

where, D_i is calculated onroad distance travelled by the vehicle between the traces T_{i-1} and T_i and l_i and l_{i-1} are the matched segment IDs', correspondingly .

- The simplicity of the above mentioned formula for onroad distance calculation is derived from the simple fact that microsegments are of equal length.

Evaluation Procedure

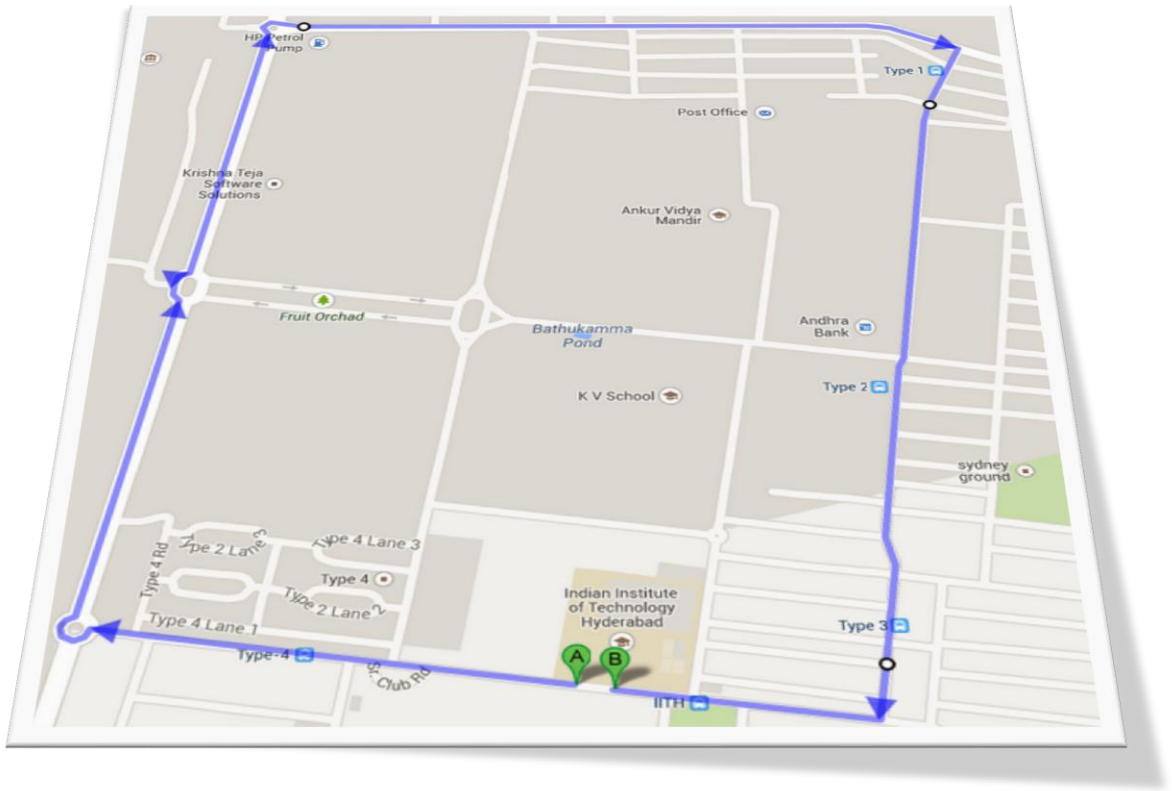
- The evaluation procedure was carried out in two phases.
  - Phase 1 : Simulated Scenario
  - Phase 2 : Real World Scenario

- Each phase can be broadly divide in three parts :
  - Data collection
  - Procedure
  - Results and Analysis

Simulated Scenario : Data collection

- The data was collected using high precision USB GPS Module connected to a Lenovo Thinkpad, which was deployed on a probe vehicle (Maruti Omni van).
- The GPS module was used at an update rate of 1 Hz.
- Each trace of the data consisted latitude, longitude, time stamp and speed.
- In the first stage the data was collected over two routes.
  1. An auto-rickshaw route (onroad length = 5.4 KM)
  2. Andhra Pradesh State Road Transport Corporation (APSRTC) Bus route 502. (onroad length = 11.7 KM)

Route 1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Post Office
Krishna Teja Software Solutions
Ankur Vidya Mandir
Fruit Orchad
Bathukamma Pond
Andhra Bank
K V School
Type 2
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Type 2 Lane 2
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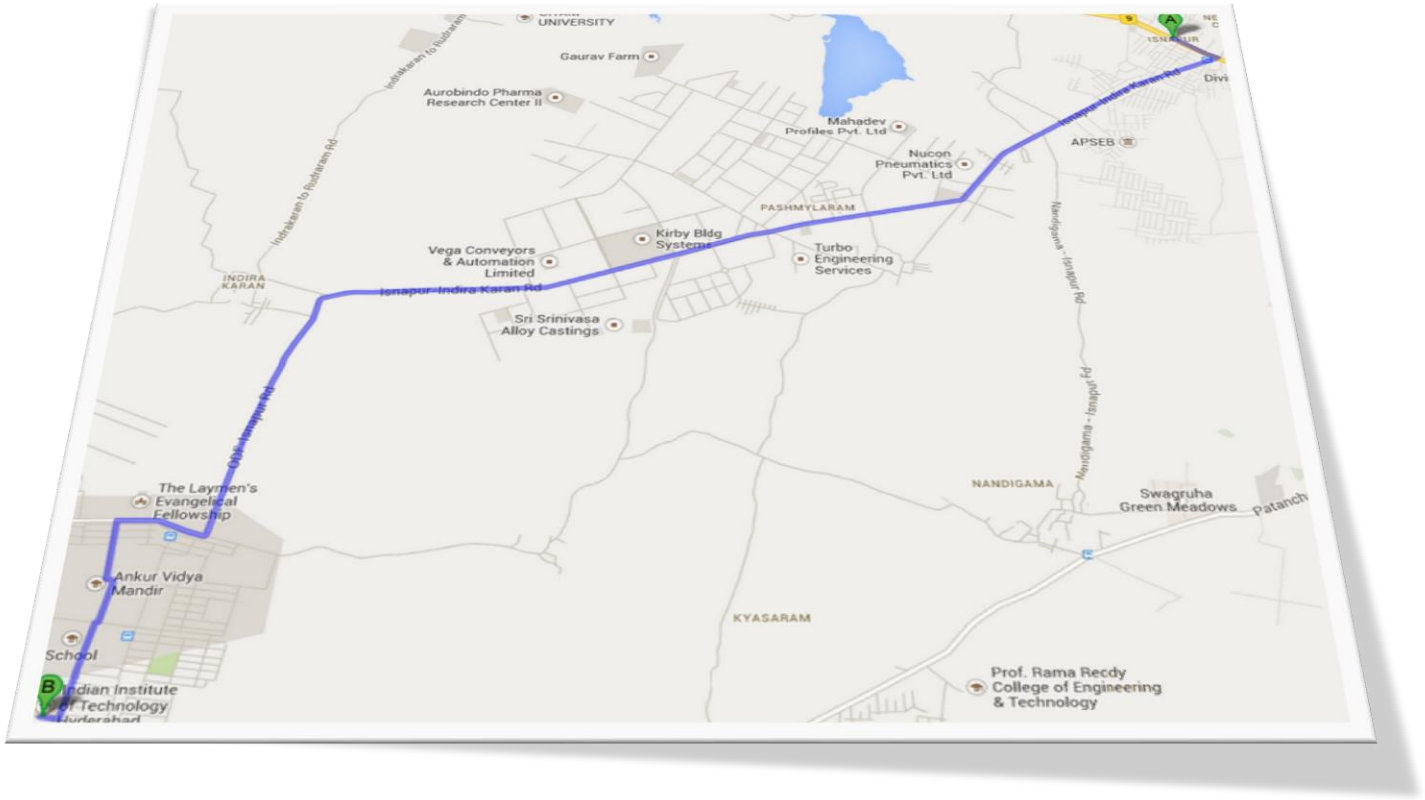
Route 2


UNIVERSITY
Gaurav Farm
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Mahadev Profiles Pvt. Ltd
Nucon Pneumatics Pvt. Ltd
APSEB
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Kirby Bldg Systems
Turbo Engineering Services
Vega Conveyors & Automation Limited
INDIRA KARAN
Ionapur-Indira Karan Rd
Sri Srinivasa Alloy Castings
Old Ionapur Rd
Nandigama - Ionapur Rd
The Laymen's Evangelical Fellowship
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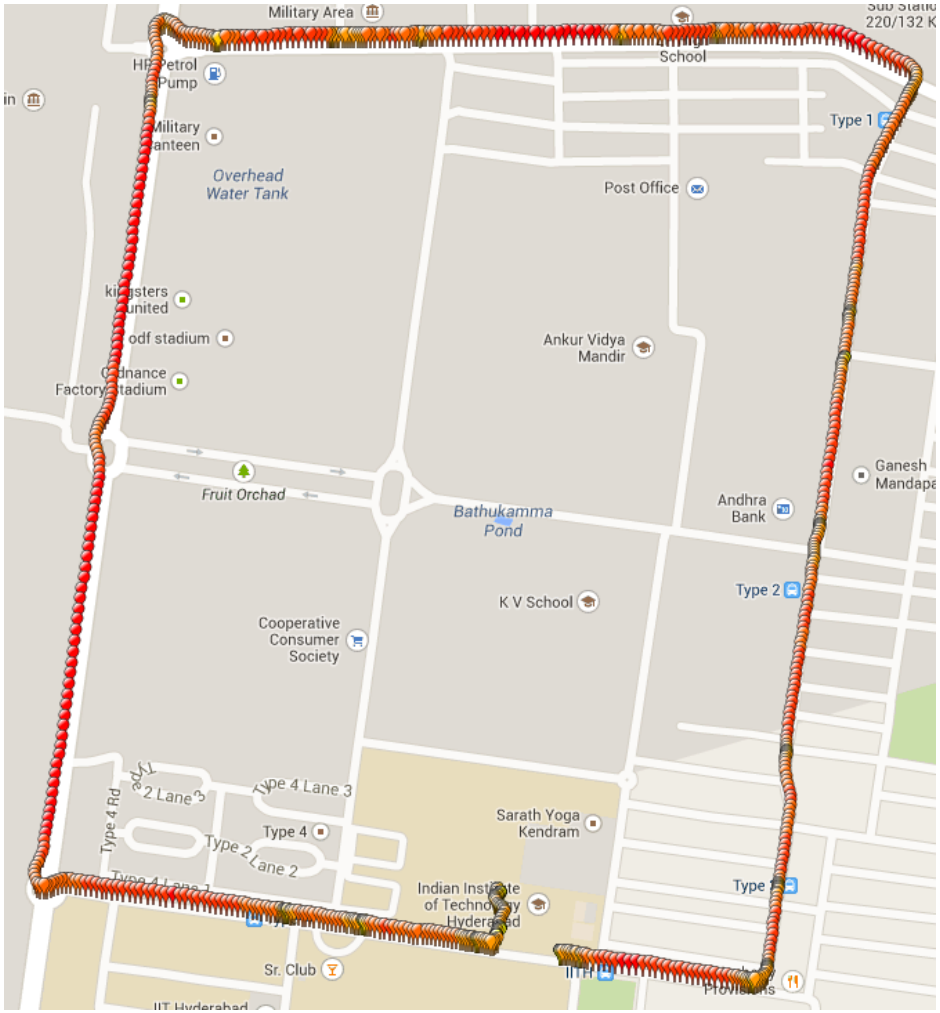
School
Indian Institute of Technology
NANDIGAMA
Swagruha Green Meadows
Patancheru
KYASARAM
Prof. Rama Reddy College of Engineering & Technology

Simulated Scenario : Procedure

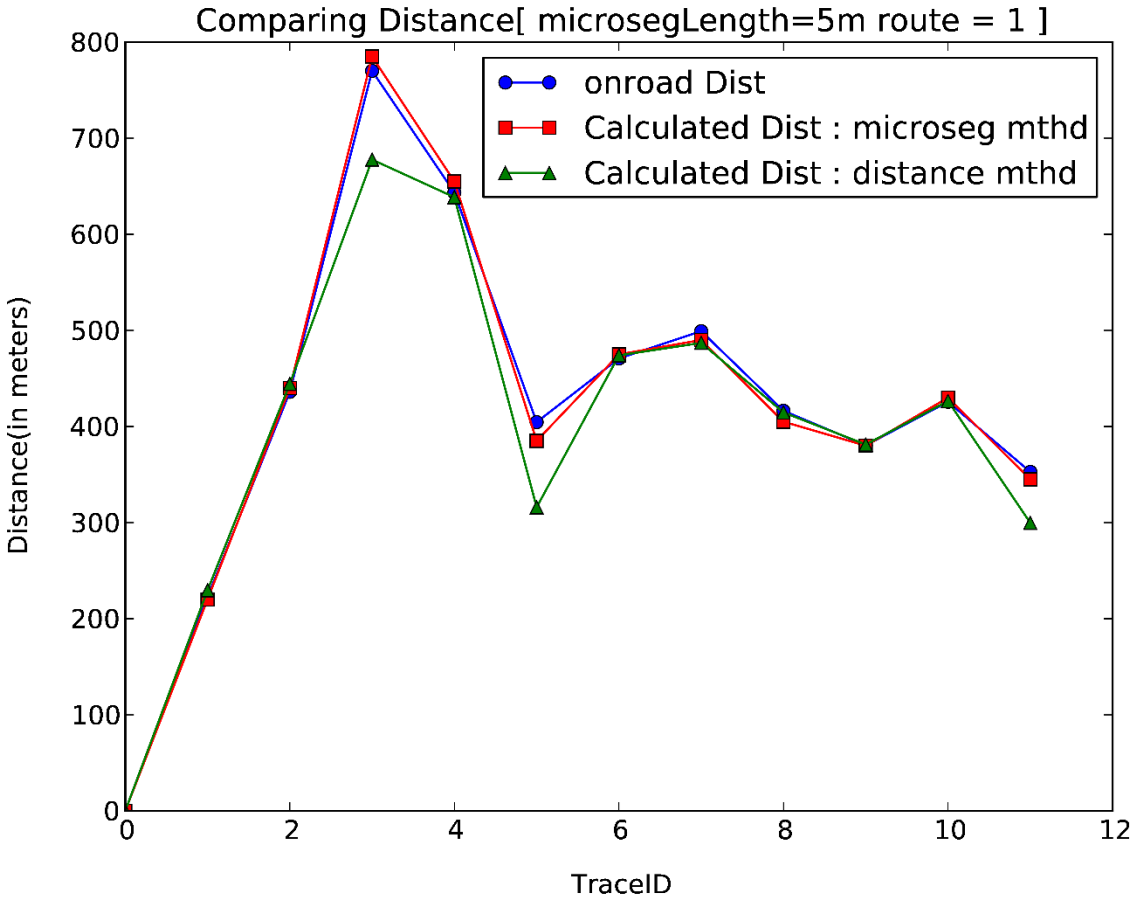
- This step can be further divided in following components :
  1. **Simulating real-world scenario** :
     - We randomly choose traces such that their difference in timestamps of consecutive traces lies between 60 to 120 seconds.
  2. **Calculating onroad distance** :
     - Using the speed data of the probe vehicle at each second of the trip, the actual onroad distance travelled was calculated.
  3. **Distance calculation *using Microsegmenting method***
  4. **Distance calculation *using Distance method***
  5. **Error Calculation**
     - The RMSE value for the results of component 3 and 4 were computed with the component 2 results as reference.

Simulating Real World Scenario

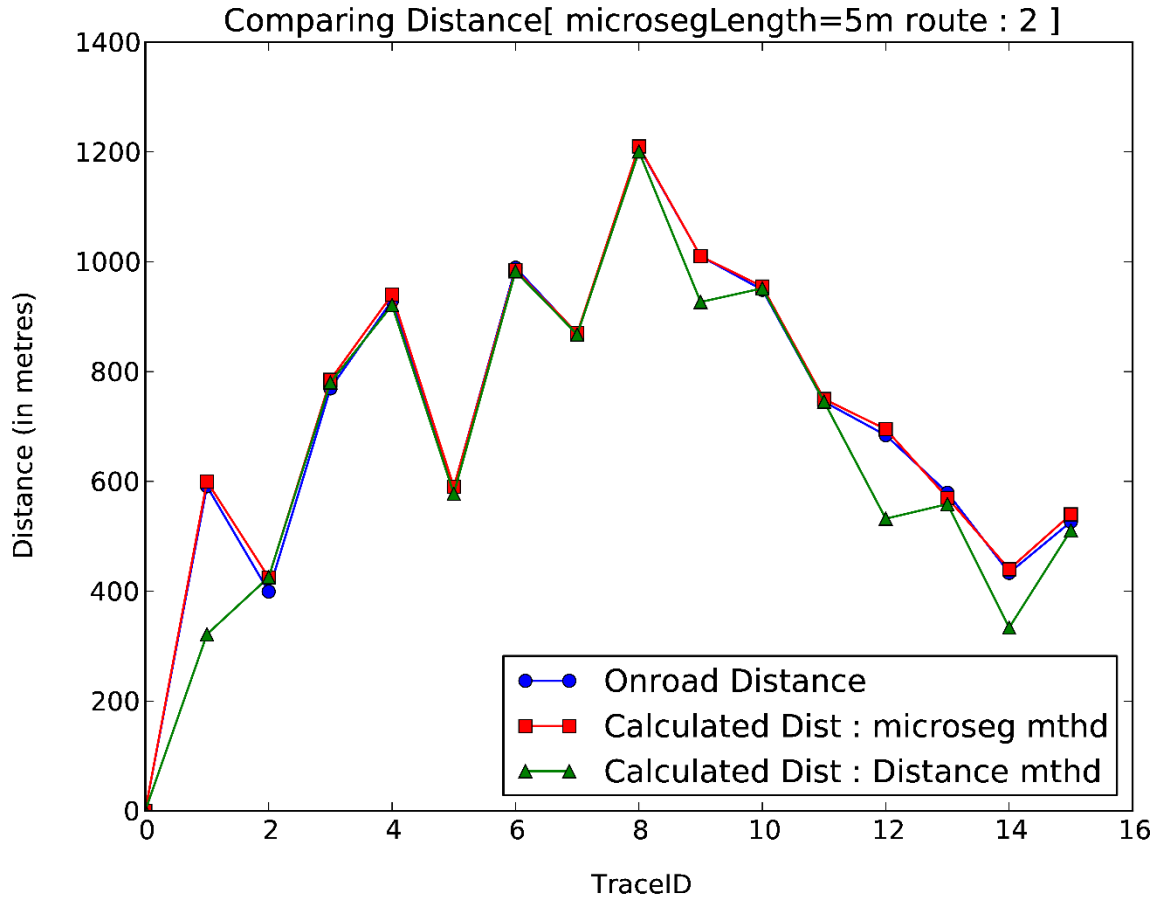


Simulating Real World Scenario

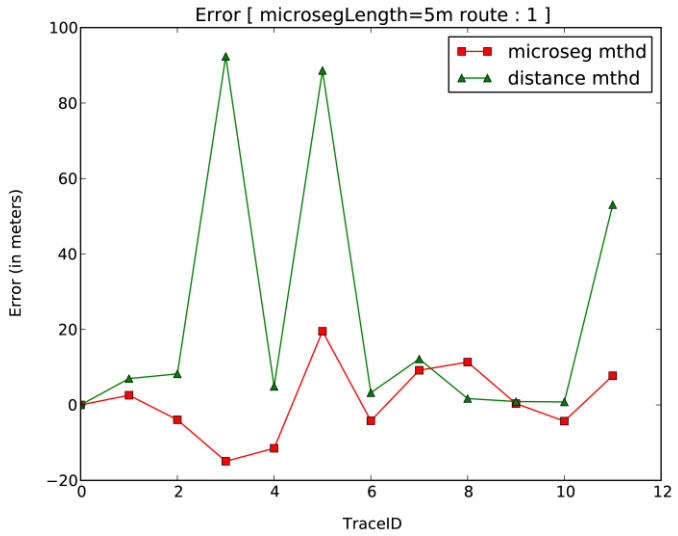
Simulated Scenario : Results (route 1)

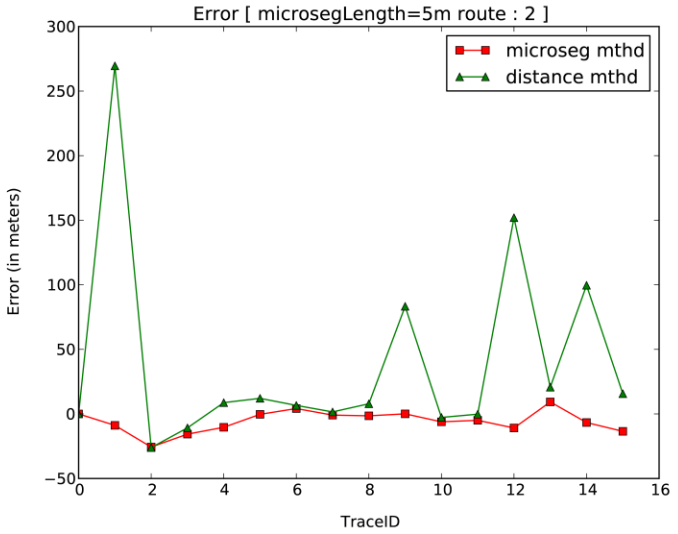


Simulated Scenario : Results (route 2)



Simulated Scenario : Performance Analysis

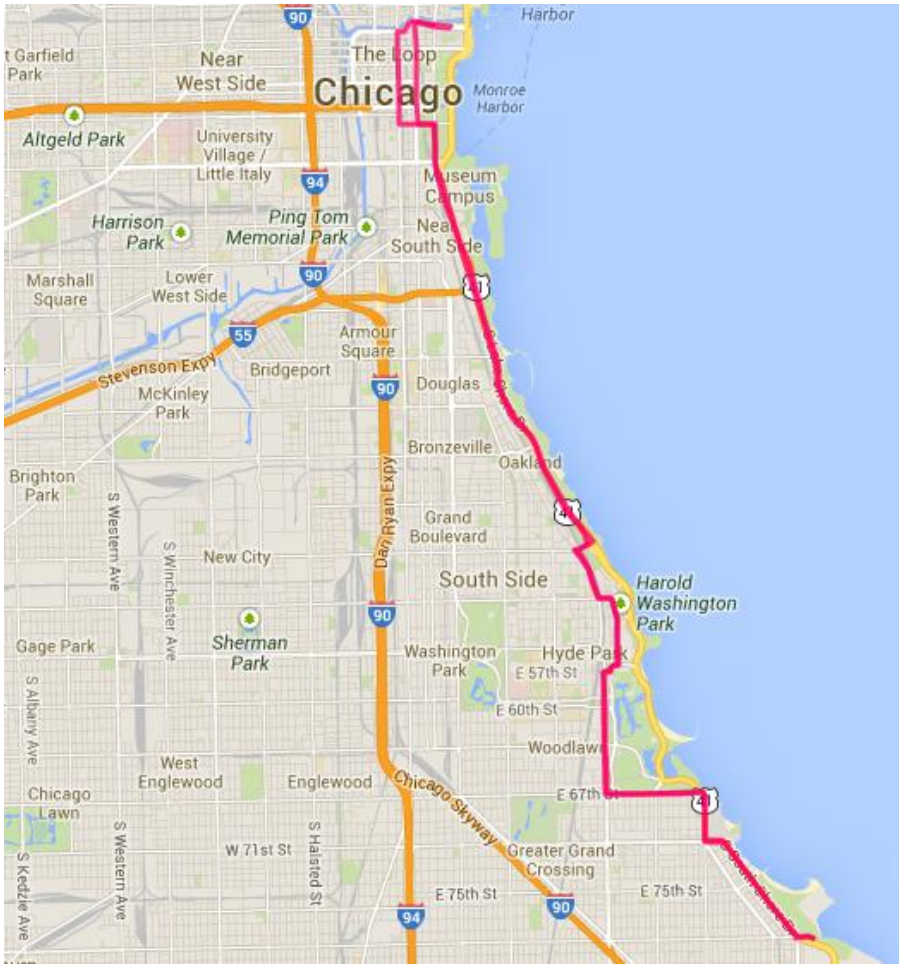




- The range of RMSE values :
  - the **microsegmenting approach** : (8m,15m).
  - the **distance method** : (57m,109m).

Real World Scenario : Data Collection

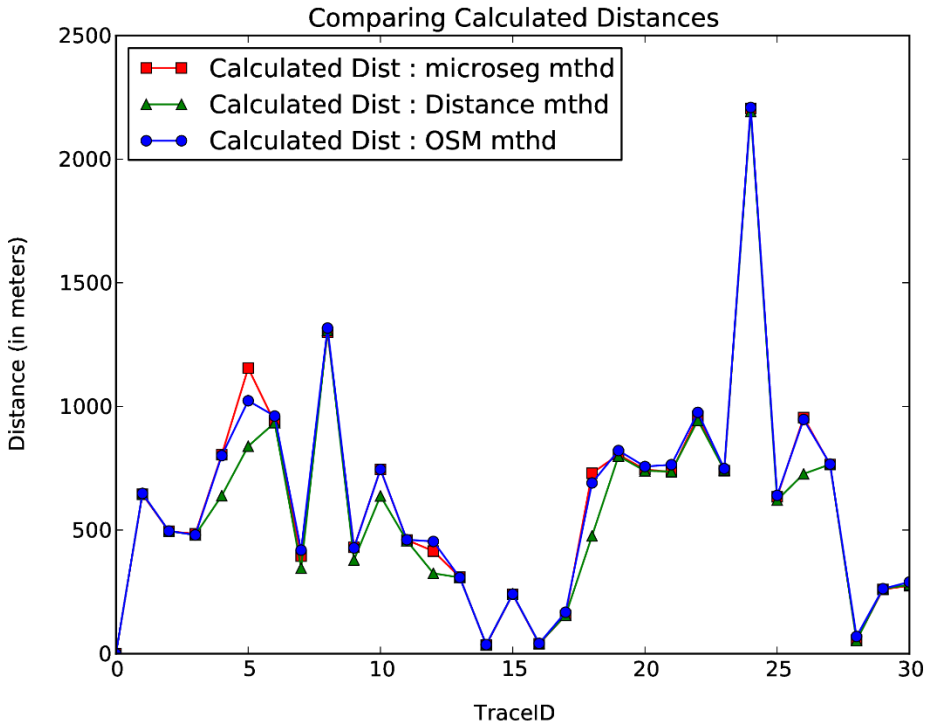
- We collected data using Chicago Transit Authority (CTA) Bus Tracker API .
- All buses under CTA are equipped with GPS devices.
- For this particular experiment we used one trip data of CTA route 6 (Jackson Park Express).



Real-World Scenario : Procedure

- The onroad distance for the CTA route 6 was calculated using the following three procedures :
  - **Microsegmenting Method**
  - **Distance Method**
  - **OSM Method** :
    - The route was segmented using OSM data points.
    - Then onroad distance was calculated by matching traces to segments and then length of all the segment lying between the matched segments were added up.
    - Additionally to improve the results albeit with huge computational cost,
      - if traces matched to same segment than then great circle distance was returned as the calculated distance
      - else the great circle distance between initial trace and its next segment's starting and the later trace and its previous segment's ending were added to the above result.

Real-World Scenario : Result



- The root mean square difference values :
  - Microsegmenting method and general method : **93.142 m**
  - Microsegmenting method and OSM method : **28.068 m**
  - OSM method and the general method : **79.298 m**

General questions

- **Is segment matching the new contribution of the work ?**
  - NO
- **Why the name microsegment and not segments ?**
  - Traditionally in ITSs' and related studies the segments are demarcated by well known spots e.g. bus stops. The segments so obtained are generally in order of 100's of meters but the microsegments were envisioned to be generally less than 10 meters.
- **Why not use OSM data instead of Microsegmenting module ?**
  - Uncontrolled and uneven length of road segment.
  - Difficulty in extraction of route data.
  - Unavailability of data for all routes.

General Questions (Contd.)

- **Why not go out physically and collect data instead of using the Microsegmenting module ?**
  - Not scalable
  - Huge scope of error

  And seriously would you ! o.O
- **Why was OSM method not considered for comparison in the simulated world Scenario ?**
  - Due to unavailability of OSM data of routes considered.

Conclusion and Future Directions

- In this work, we proposed a novel method of Microsegmenting for addressing the Displacement problem.
- We conducted a two-staged experiment to empirically analyse the performance of the proposed method.
- The results obtained were in accordance with the hypothesis and the proposed technique of microsegmenting showed a significant improvement over the distance and OSM method.
- The evaluation procedure was not based on live data but the proposed method can also be similarly applied in real-time setups.
- In our present implementation, the vertices of the polyline used to approximate the route are obtained manually, in future we aim to automate this process.

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Thank you!

Feedback ?

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