FOSS4G BELGIUM 2016

ceci n'est pas une conférence

3rd Degree Polynomial Curve Fitting Approach To Improve OpenStreetMap Derived Curved Road Lengths

OSGeo

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About Me

- Currently doing *Doctoral of Philosophy* at Istanbul Technical University[1] under the Department of Geomatics Engineering.
- Additionally, working as a *Full Stack GeoSpatial Developer* at National Innovation and Research Center for Geographical Information Technologies[2] (Istanbul Technical University).

Funding 💰

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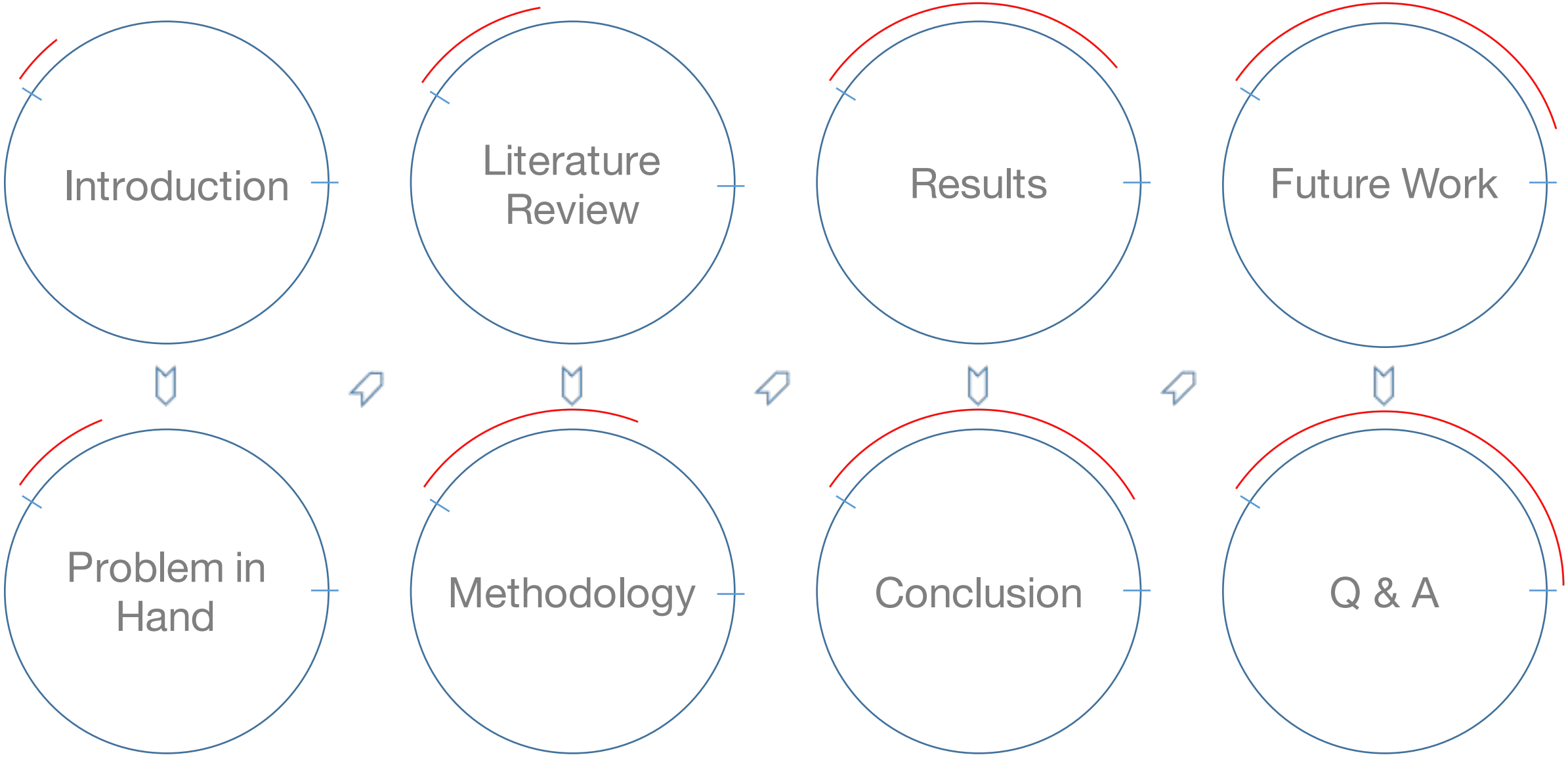
Content


Introduction
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Future Work
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Q & A

Introduction

2004 -

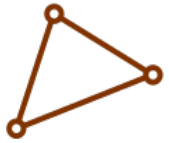
OpenStreetMap (OSM) is currently one of the most popular Volunteered Geographic Information (VGI) project with objective to establish a free and editable street map of the world.

OSM Statistics September 2015

8 billion nodes

3 billion ways

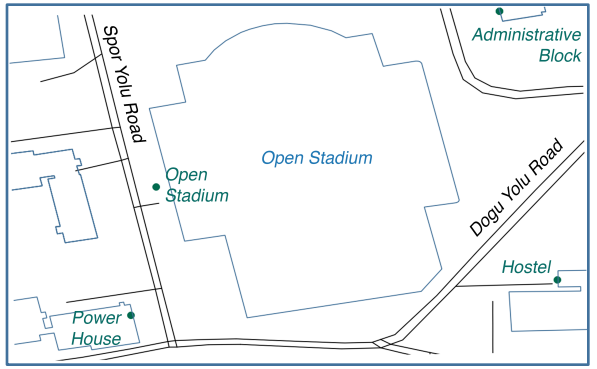
4 million relations



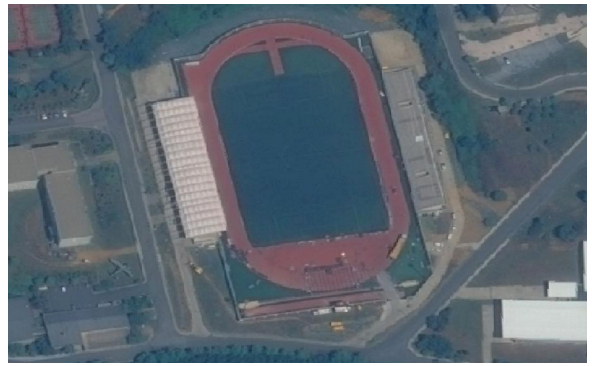
2.5 million users

OSM Data Format

Vector

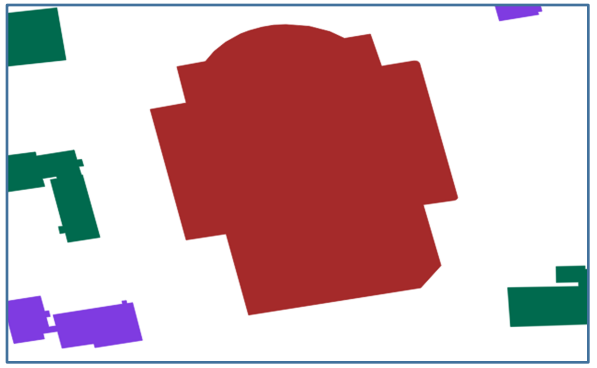


Raster

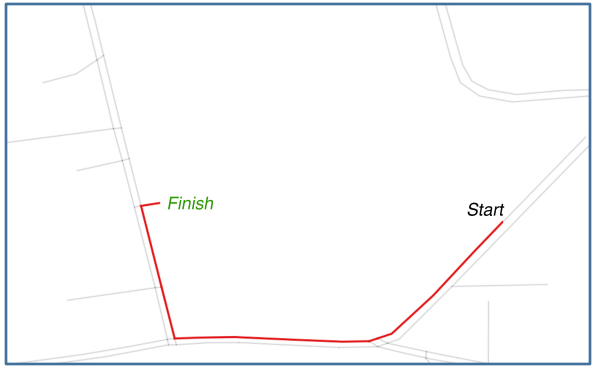


OSM Applications

Thematic Maps



Routing Services



Problem in Hand?

OSM XML Format

```
<?xml version="1.0" encoding="UTF-8"?>
<osm>
    <node/>
    <node/>
    <node/>
    <node/>
    <node/>
    <node/>
    <way></way>
    <relation></relation>
</osm>
```

Point

Polygon

Line

A Small Road Section

Problem in Hand? . . .

OSM Road Euclidean Length

OSM Road Curve Fitted Length

Euclidean Length $\leq$ Curve Fitted Length

Literature Review

Road Length Amelioration
No Similar Work!

Vandalism

Road Classification

Different Applications

OSM Dataset Time-Series Evolution

3D Modelling

OSM Semantics

Case Studies

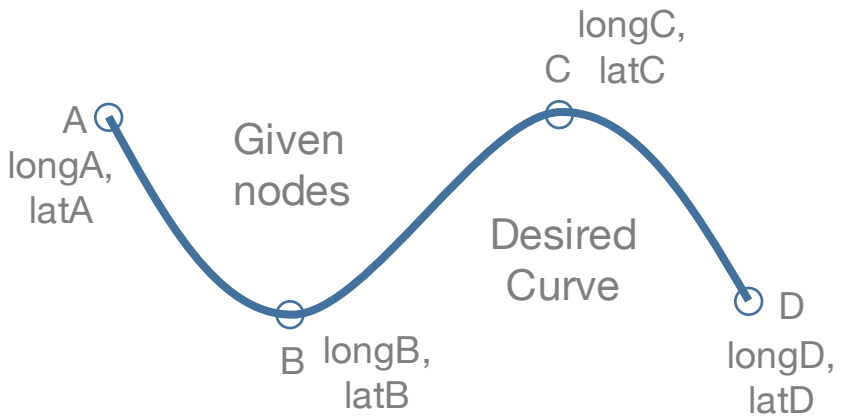
Quality Check-Up

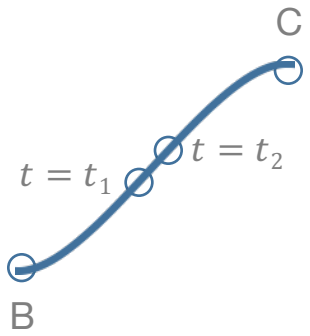
Urban Planning

Vehicle Traffic

Methodology

Cubic Curve Equation Derivation





Parametric curve equation of 3rd degree

$$long(t) = x = f(t) = a_1t^3 + b_1t^2 + c_1t + d_1$$

$$lat(t) = y = g(t) = e_1t^3 + f_1t^2 + g_1t + h_1$$

Length from t_1 to t_2 (using mean-value theorem)

$$(1)\ L(in\ radian) = \int_{t_1}^{t_2} \left[\sqrt{ \{ \frac{df(t)}{dt} \times \frac{[\cos\{g(t_1)\} + \cos\{g(t_2)\}]}{2} \}^2 + \{ \frac{dg(t)}{dt} \}^2 } \right] dt$$

$(2)\ Applying\ Simpson's\ rule\ to\ solve\ L(in\ radian)$

$(3)\ L(in\ meter) = RadiusEarth(lat_1) \times L(in\ radian)$

$(4)\ Summing\ up\ all\ segments\ from\ B\ to\ C$

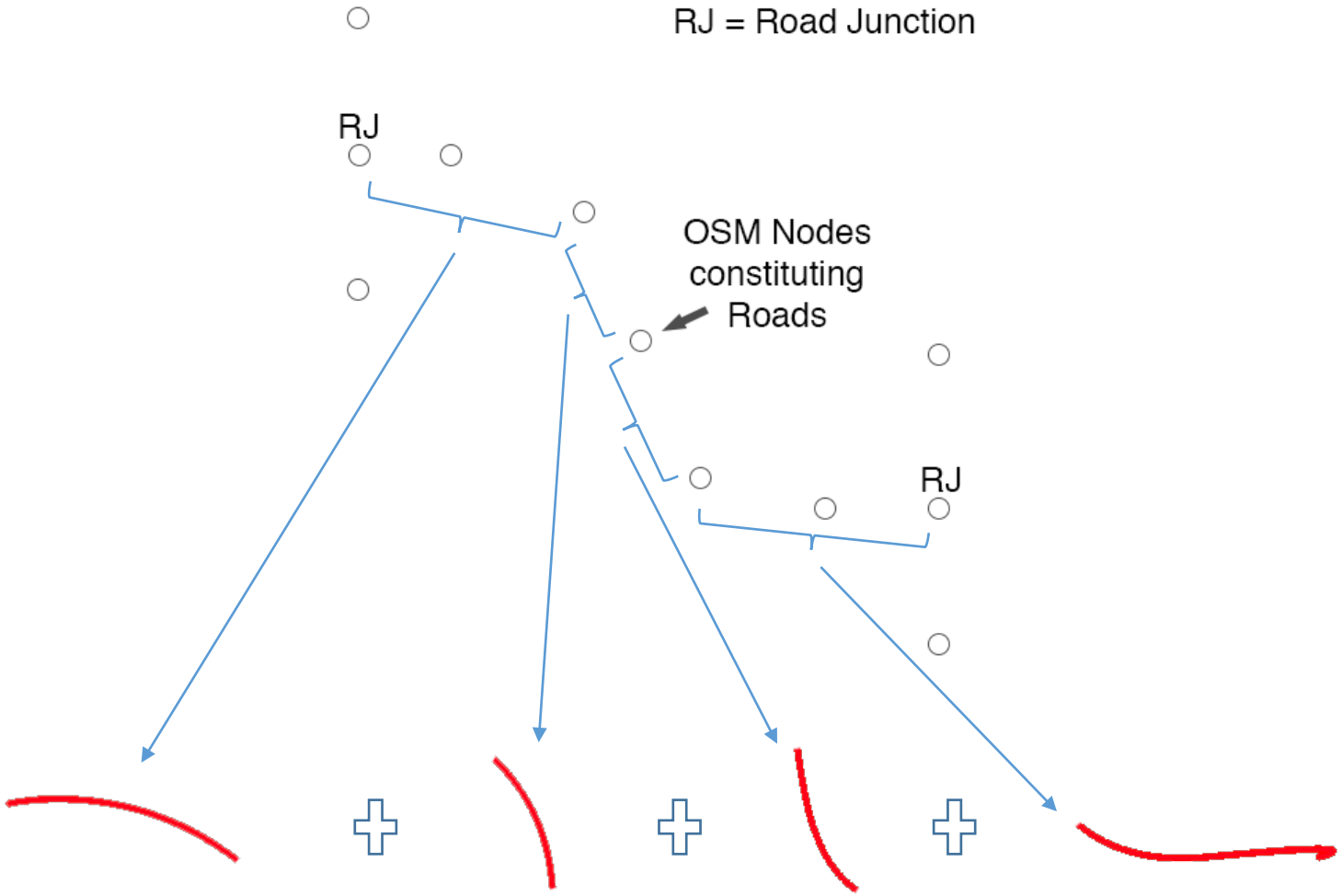
$$RadiusEarth(lat_1) = ((\{\cos lat_1\}/a)^2 + (\{\sin lat_1\}/c)^2)^{-0.5}$$

$$\tan lat_1 = (c/a)^2 \times \tan\{latt_{mean}\}$$

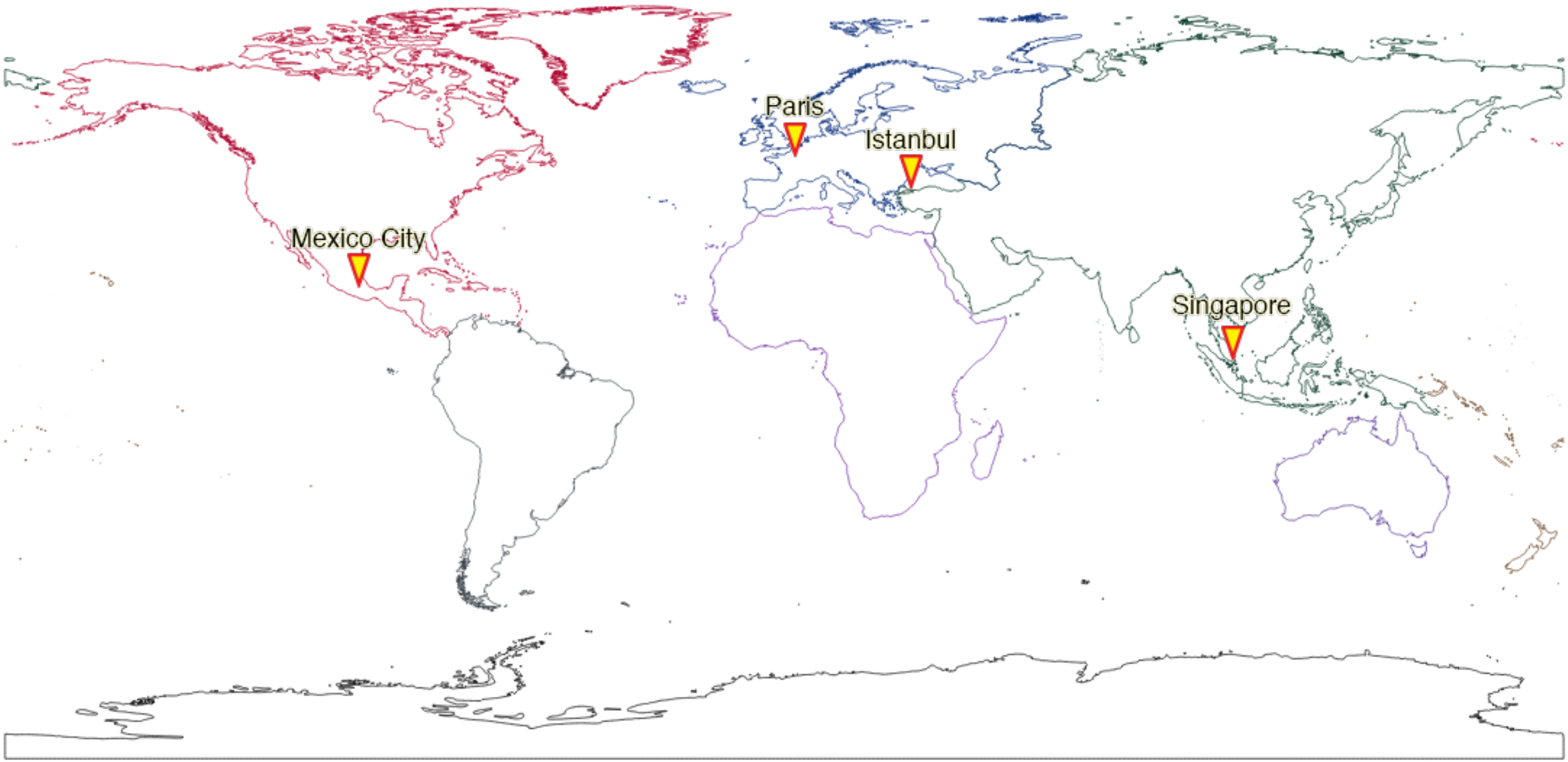
$$lat_{t\ mean} = \frac{\{latt_1, latt_2\}}{2}$$

where a is equatorial and c polar radius

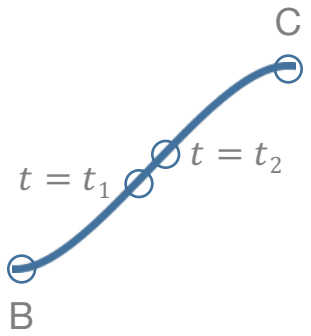
Methodology

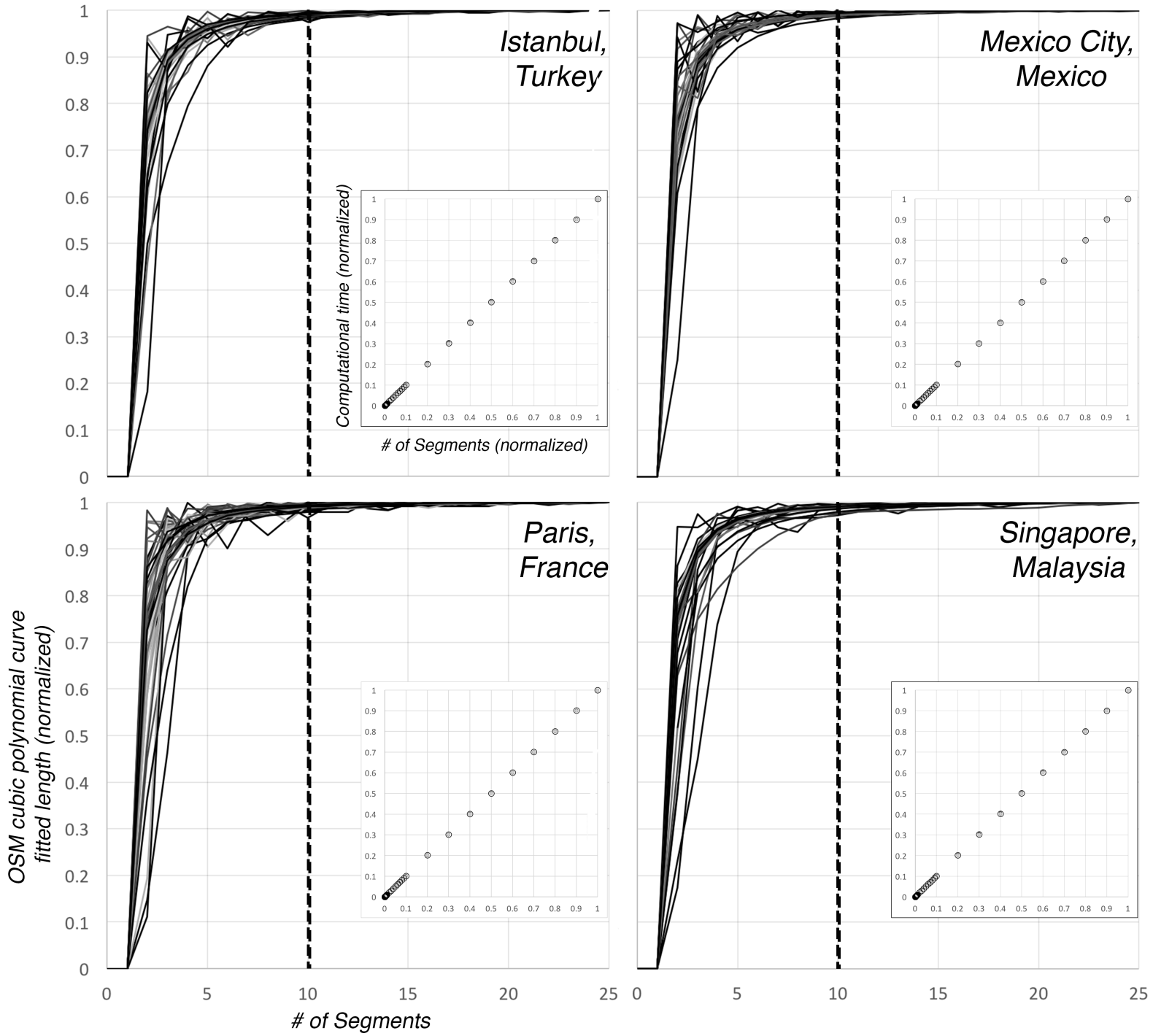


Results



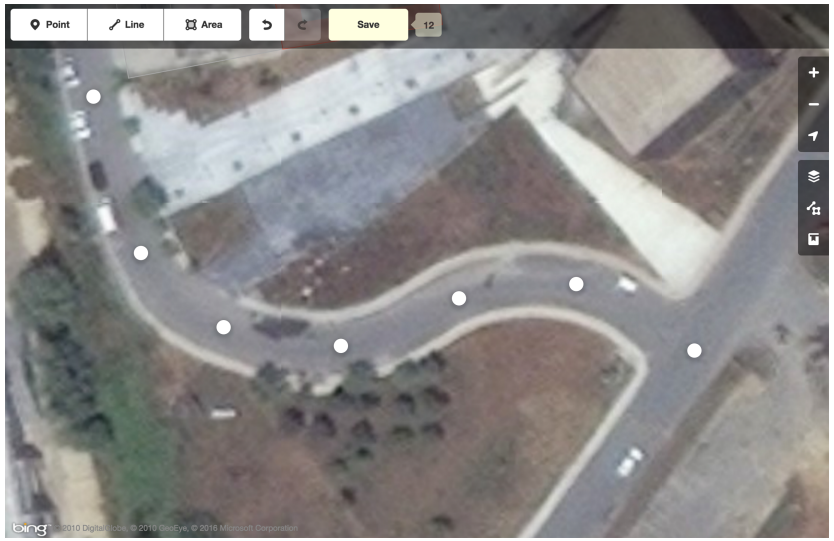
Results . . .


C
$t = t_2$
$t = t_1$
B


Istanbul, Turkey
Mexico City, Mexico
Paris, France
Singapore, Malaysia
Computational time (normalized)
# of Segments (normalized)
OSM cubic polynomial curve fitted length (normalized)
# of Segments

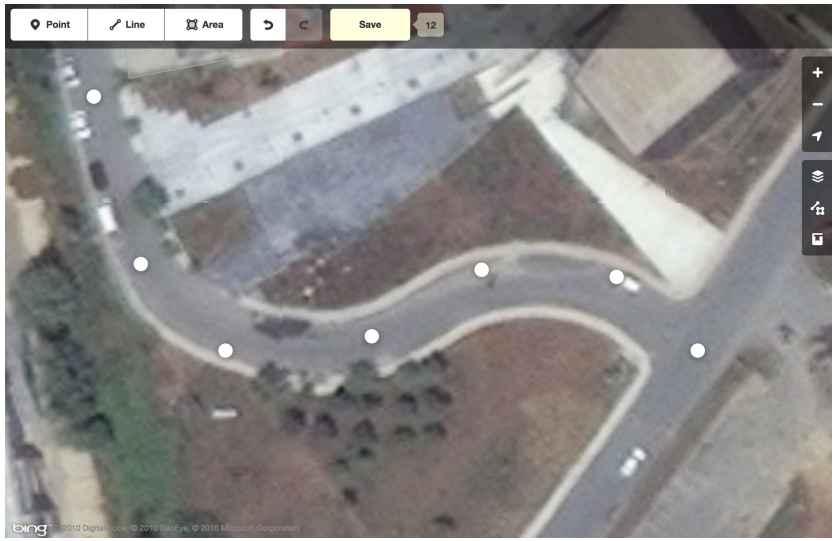
Results . . .

Nodes Precisely Mapped



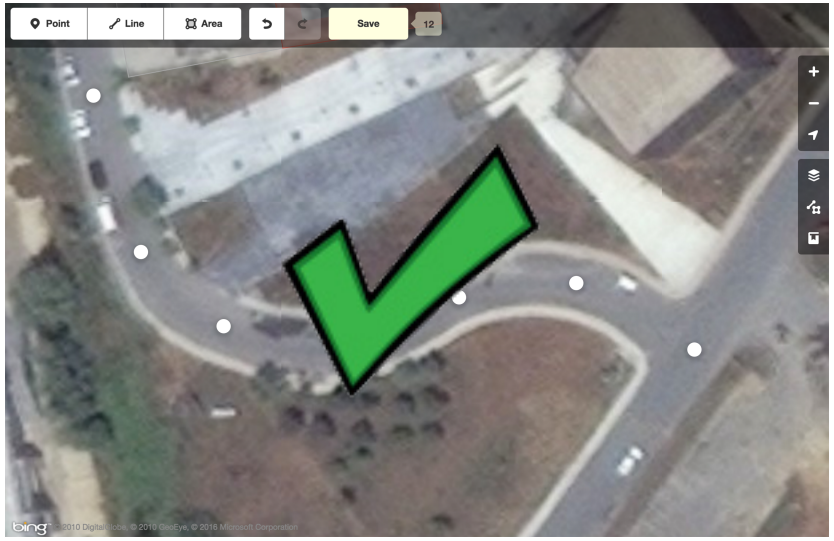
Road Curvature Underestimated

Road Curvature Overestimated



Results . . .

Nodes Precisely Mapped



Road Curvature Underestimated

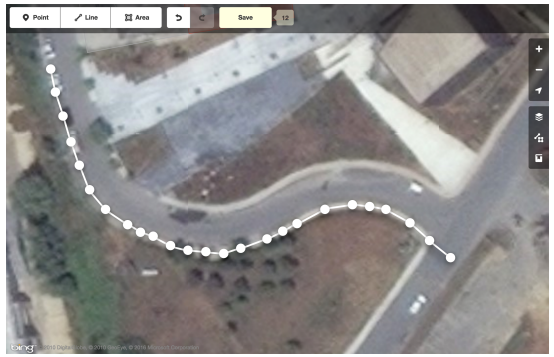
Road Curvature Overestimated

Euclidean Length ≤ Curve Fitted Length

Results . . .

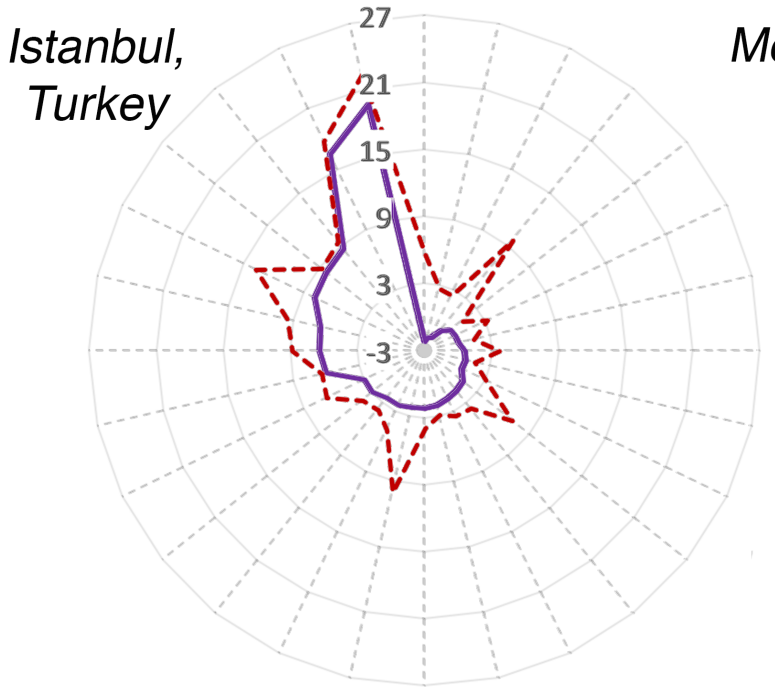
Euclidean Length

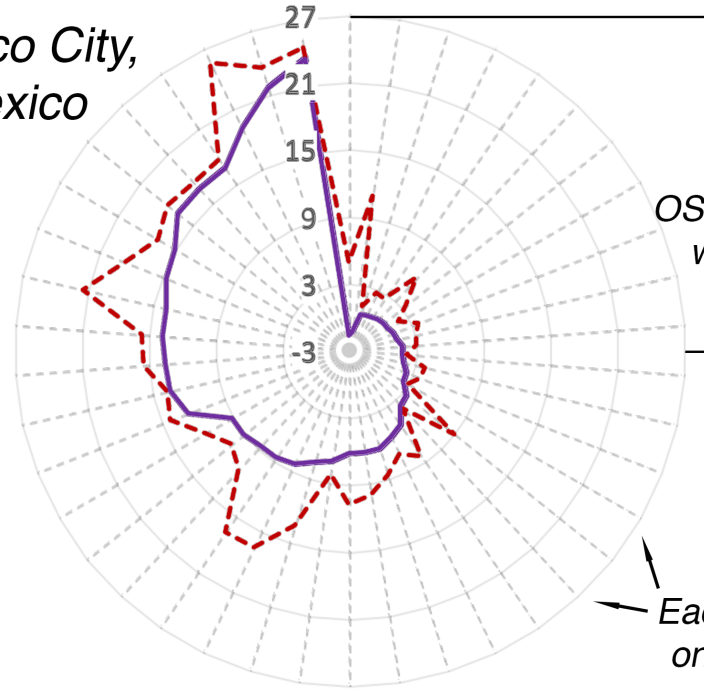
Curve Fitted Length



Best Length

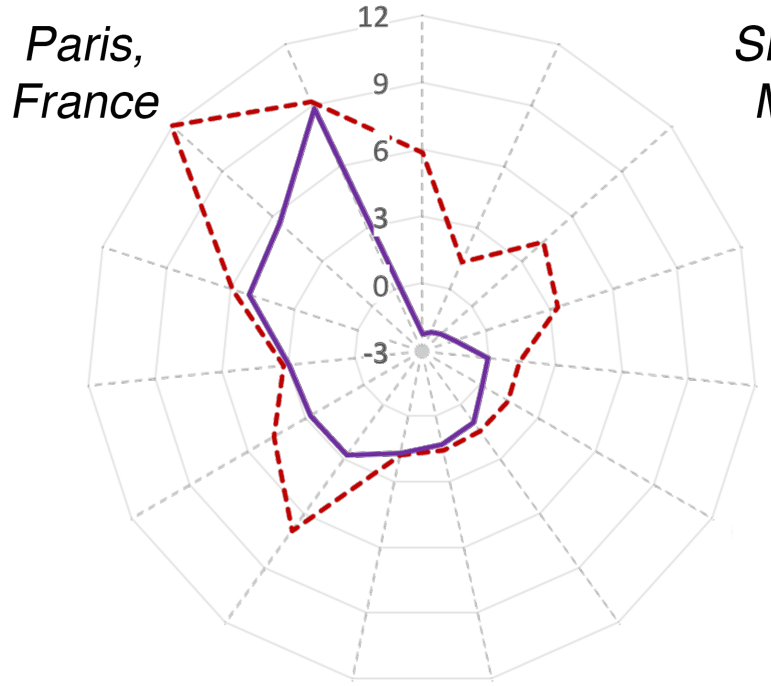
Results . . .

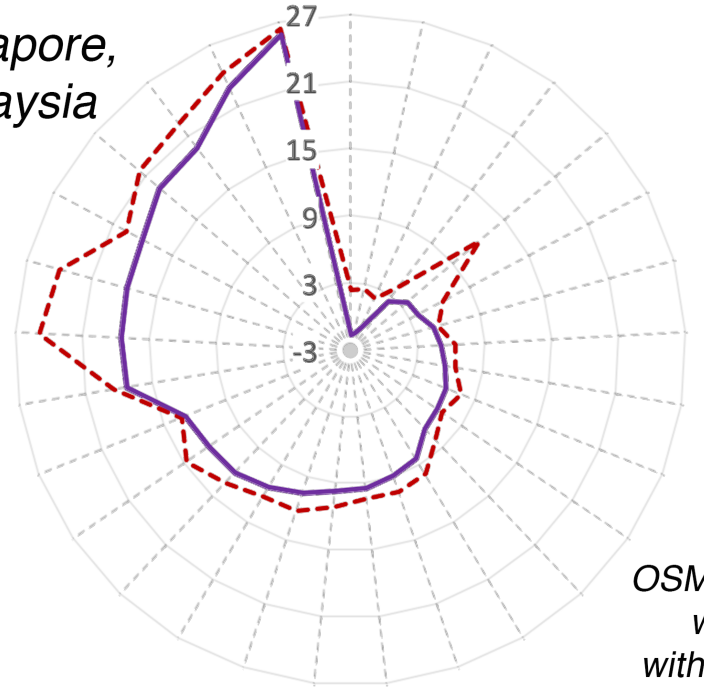




Manually mapped road length - OSM derived road length with/without curve fit (meters)

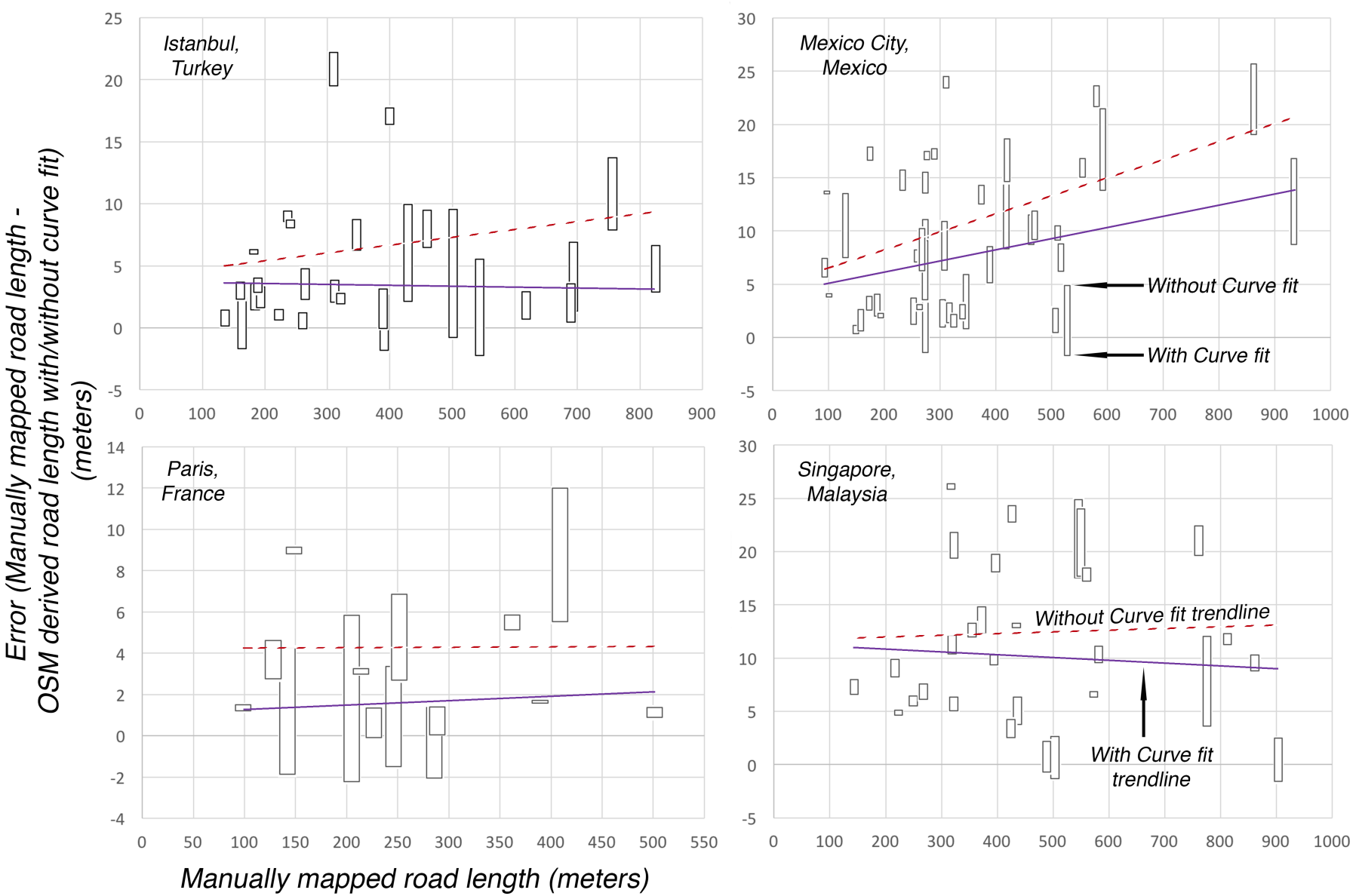
Each vertex represents one analysed curved road section

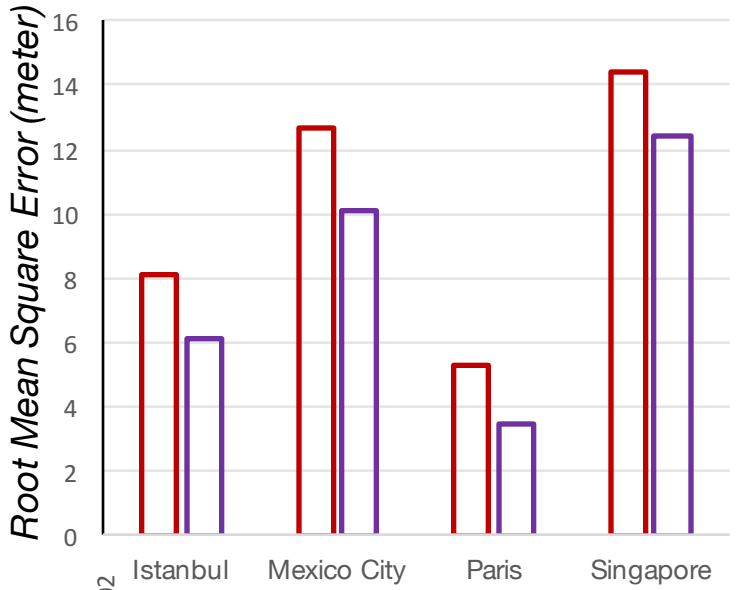


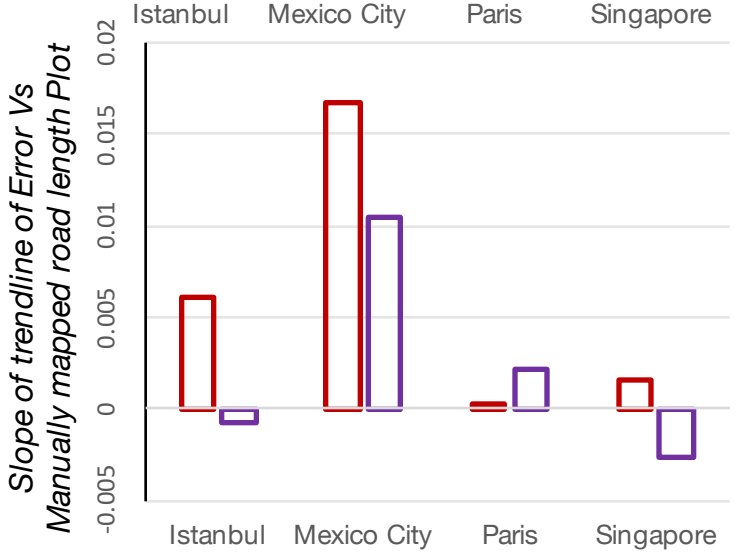


OSM derived road with curve fit - ——
without curve fit - - - - - -

Results . . .


Istanbul, Turkey
Mexico City, Mexico
Paris, France
Singapore, Malaysia
Without Curve fit
With Curve fit
Without Curve fit trendline
With Curve fit trendline
Error (Manually mapped road length - OSM derived road length with/without curve fit) (meters)
Manually mapped road length (meters)


Root Mean Square Error (meter)
Istanbul
Mexico City
Paris
Singapore


Slope of trendline of Error Vs Manually mapped road length Plot
Istanbul
Mexico City
Paris
Singapore

Conclusion

- Curve Fitted Road Length is better than Euclidean Length.
- Proposed algorithm, although, can not be used for a whole city blindly.
- For overly mapped curved road lengths it will bring more error than Euclidean Length.
- 10 number of road segmentation during formulation is apt for OSM data, after preliminary results.

Future Work

- Developing an automated way to estimate overly estimated road curves.
- A web-GUI to visualize fitted curve.
- A methodology to remove nodes causing curvature over estimation.
- Cross checking results with some proprietary or governmental data.
- Running developed algorithm on other similar cities.

Thanks!

Any questions?

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 Zia- (This presentation will get online soon at author's GitHub accout!)