

# LOCAL ANOMALY DETECTION IN MARITIME TRAFFIC USING VISUAL ANALYTICS

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March 23, 2021

# Outline

- Motivation
- Main Problems
- Solution
- Live Demo
- Discussion

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# Motivation

**“Crime on the high seas is becoming increasingly sophisticated, endangering human life on land, the economic growth of entire regions and global safety, the head of the United Nations anti-crime agency warned the Security Council today”**

United Nations, February, 2019

## Piracy



## Pollution



## Illegal fishing



## Drug trafficking





*Credit: Leading Seaman Dan Bard,  
Formation Imaging Services.*

*Halifax Marine Security Operations Centre*

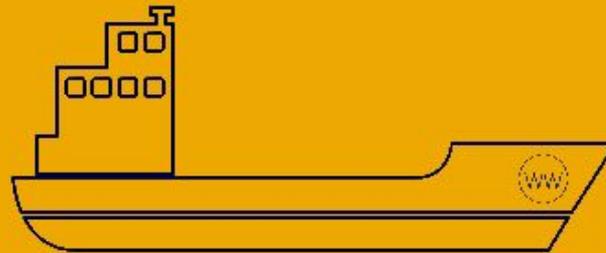
**90% world trade**



**will grow 3x by 2050**

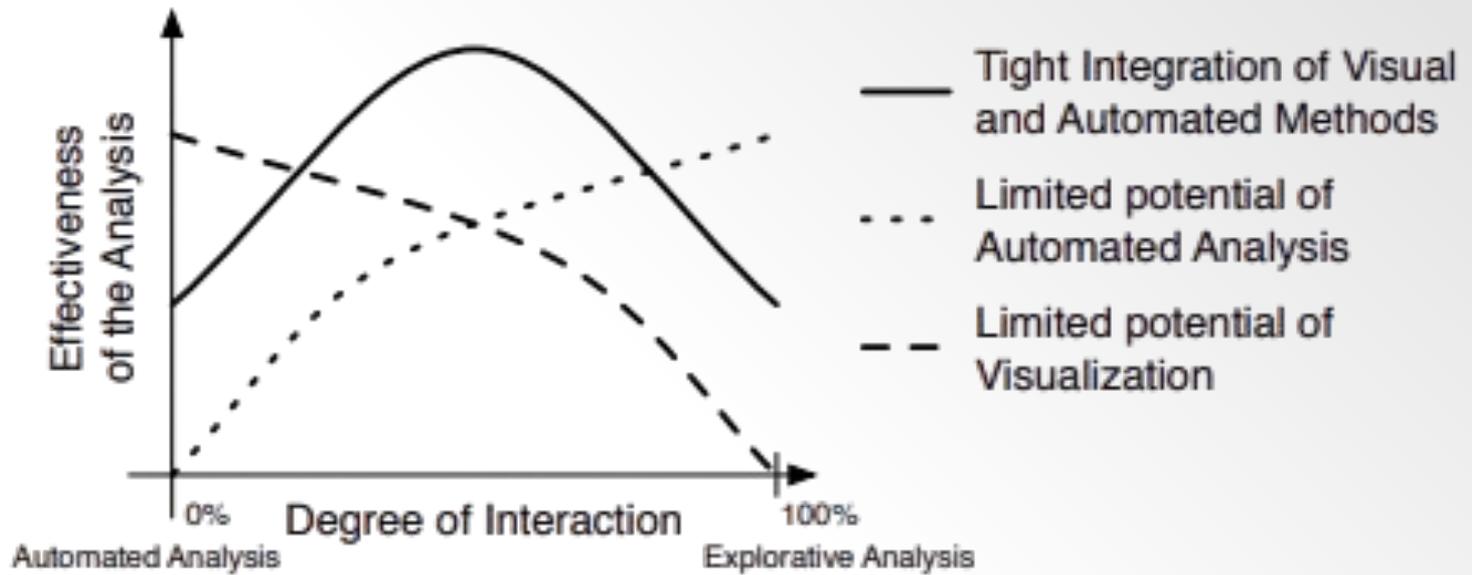


In a typical month  
half of all tankers will have  
AIS Transmission Gaps



“autonomous anomaly detection systems are rarely used in the real world.”

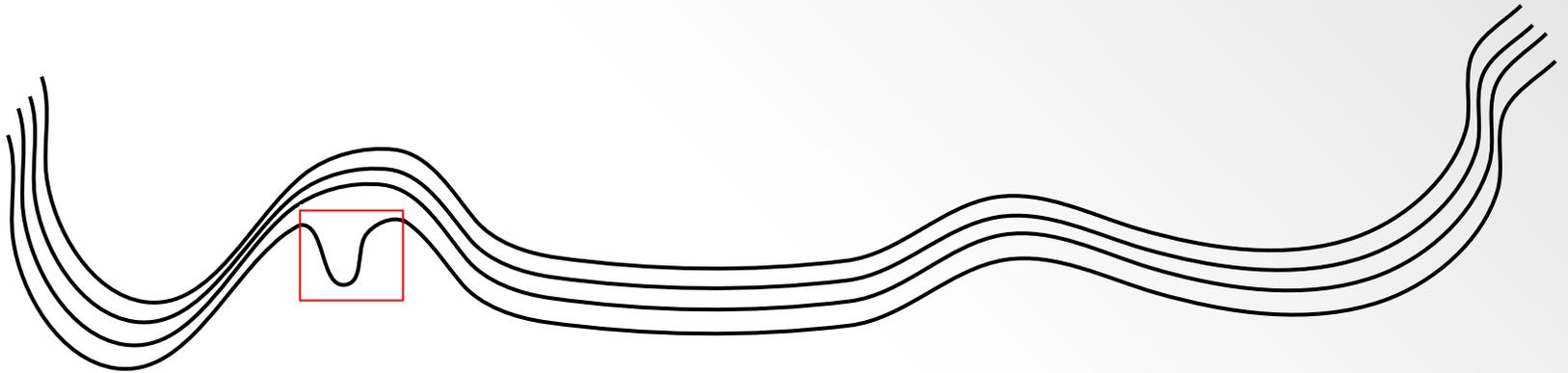
(Riviero et. al 2009)



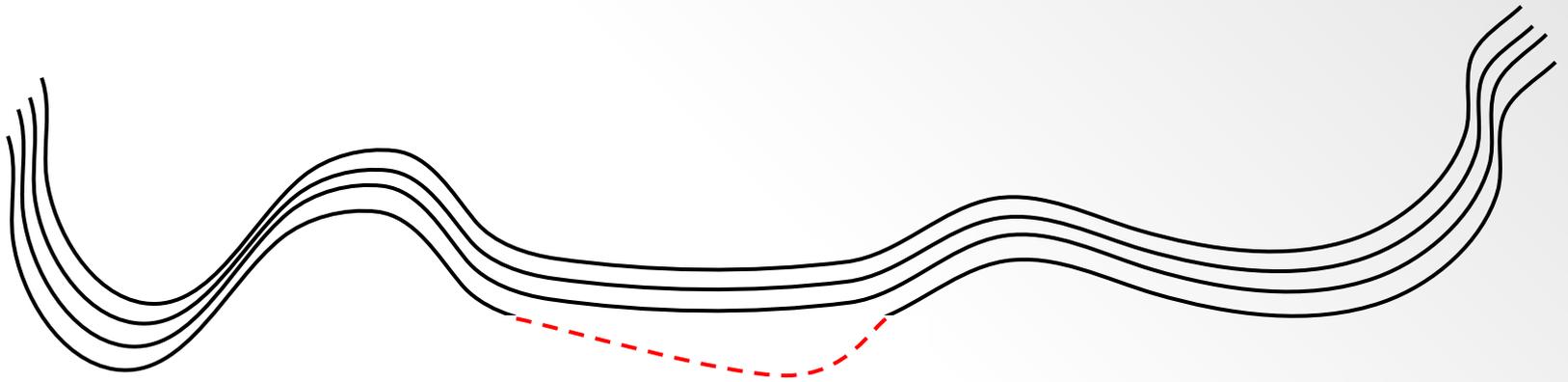
# Main problems

<b>Work</b>	<b>Domain</b>	<b>Anomaly scope</b>	<b>#Attributes</b>	<b>Prioritization</b>	<b>Interpolation Factor</b>
Willems et al. (2009) [54]	maritime	global	2	no	no
Scheepens et al. (2011) [42]	maritime	global	3+	no	no
Willems et al. (2010) [55]	maritime	global	3+	no	no
Lavigne (2014) [22]	maritime	global	3+	no	no
Wang et al. (2017) [53]	maritime	local	1	no	no
Riviero et al. (2009) [40]	maritime	global	3+	no	no
Guo et al. (2011) [13]	road	global	3+	no	no
Lu et al. (2015) [29]	road	global and local	2	yes	no
Tominski et al. (2012) [49]	generic	global and local	3+	no	no
<b>This work</b>	maritime	global and local	3+	yes	yes

# Local anomalies



# Uncertainty caused by interpolation

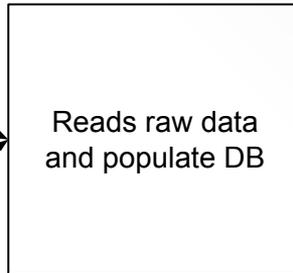


# Solution

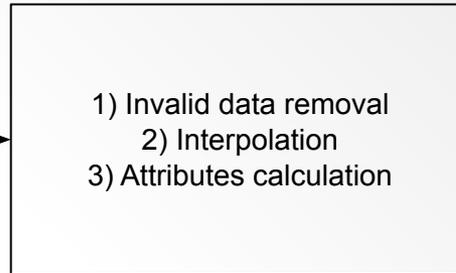
## Raw Data

## Preprocessing

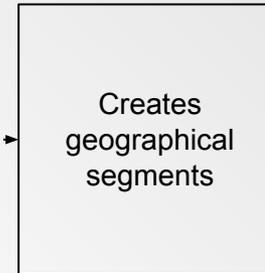
### Integration



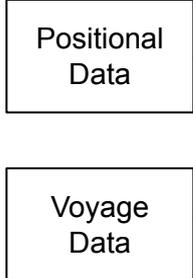
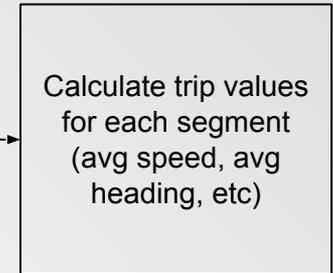
### Cleaning



### Segmentation

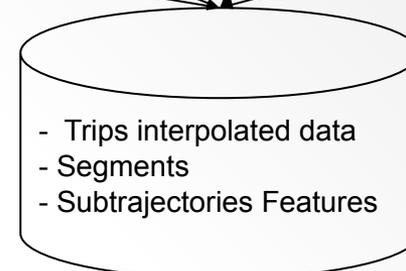


### Feature Extraction

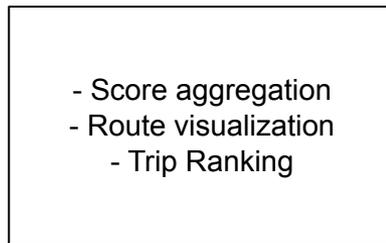


.csv

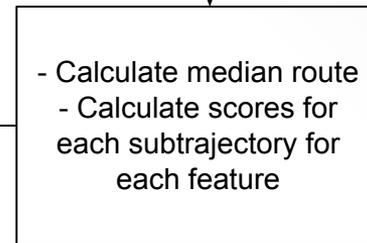
.csv



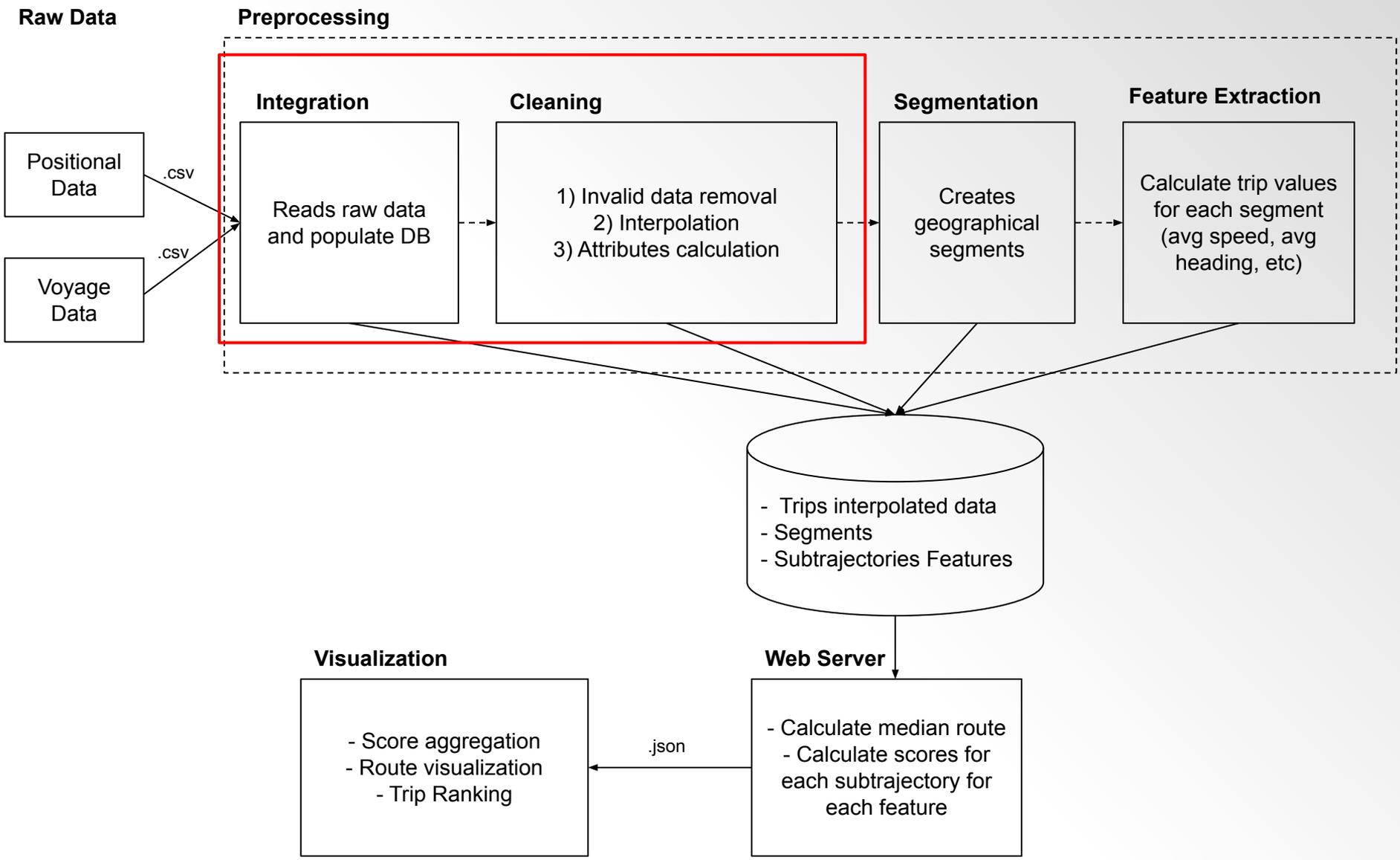
### Visualization

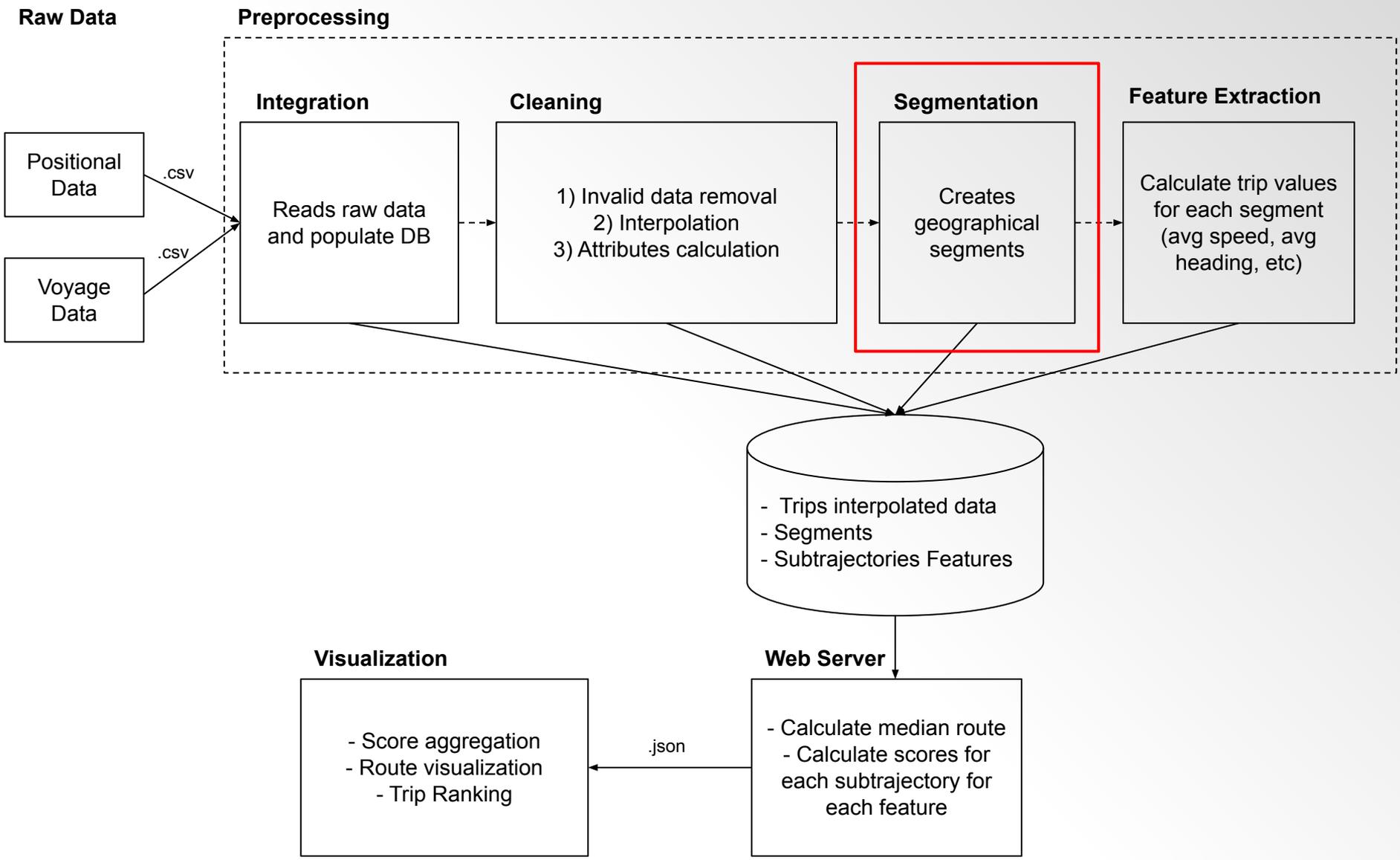


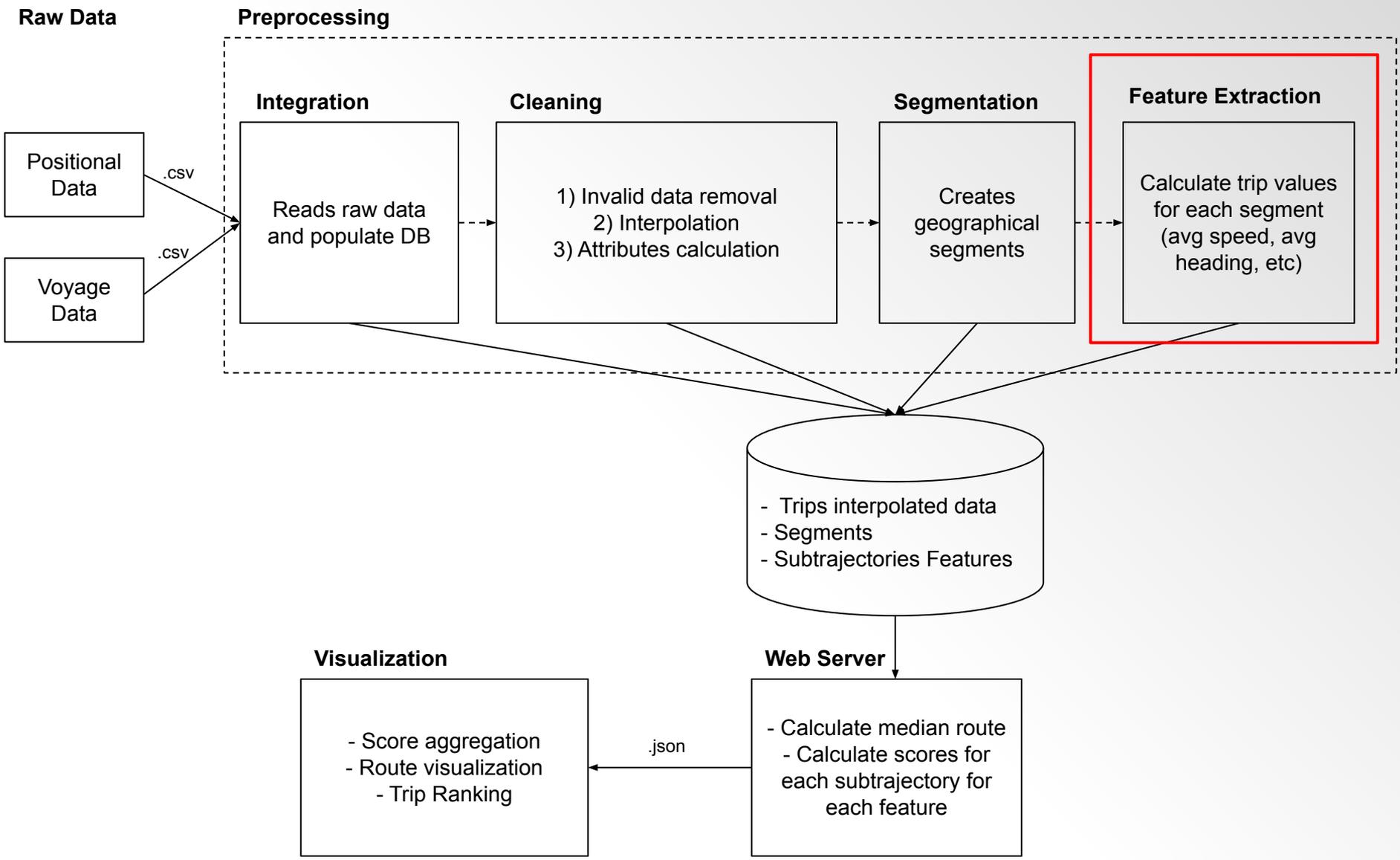
### Web Server

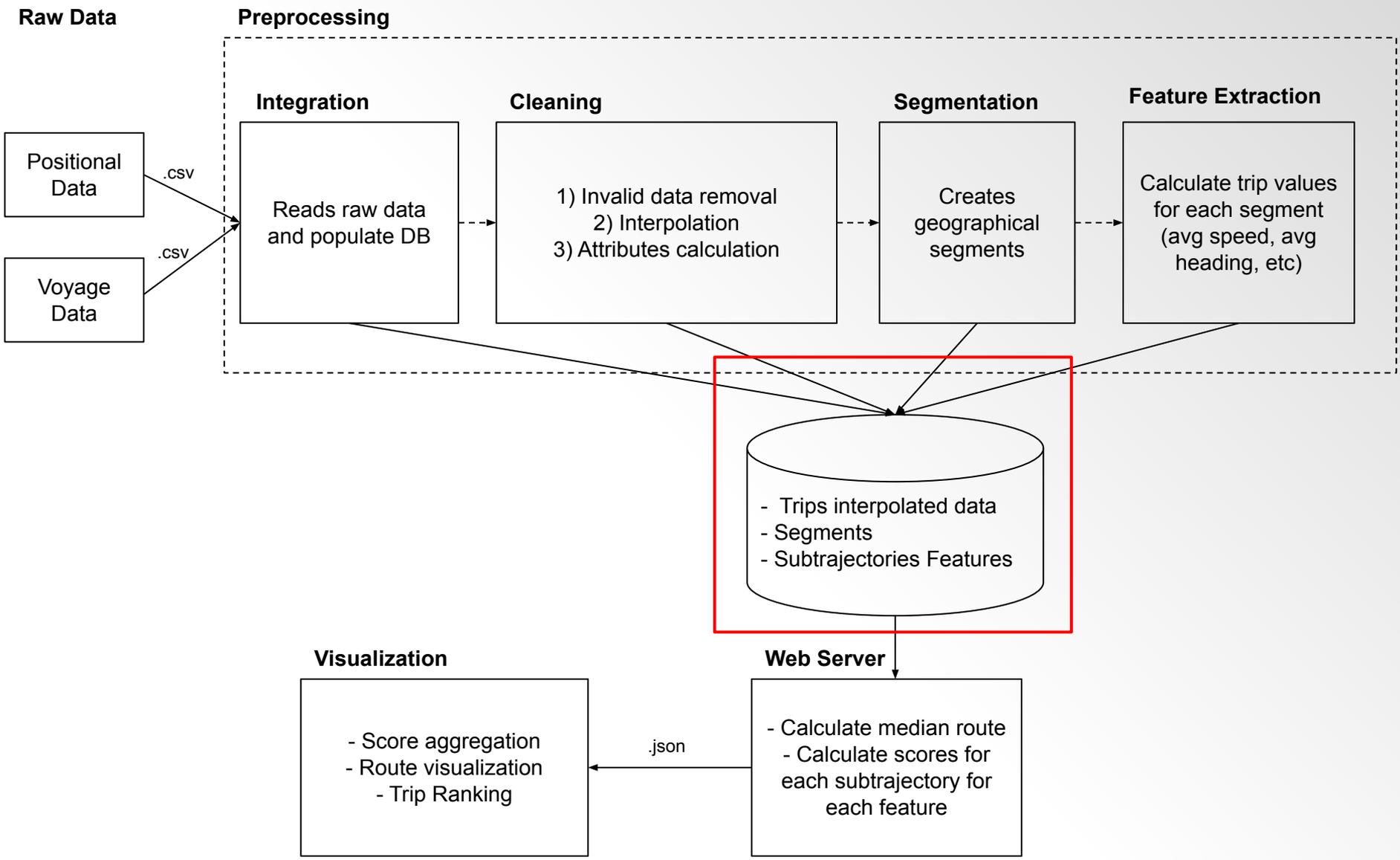


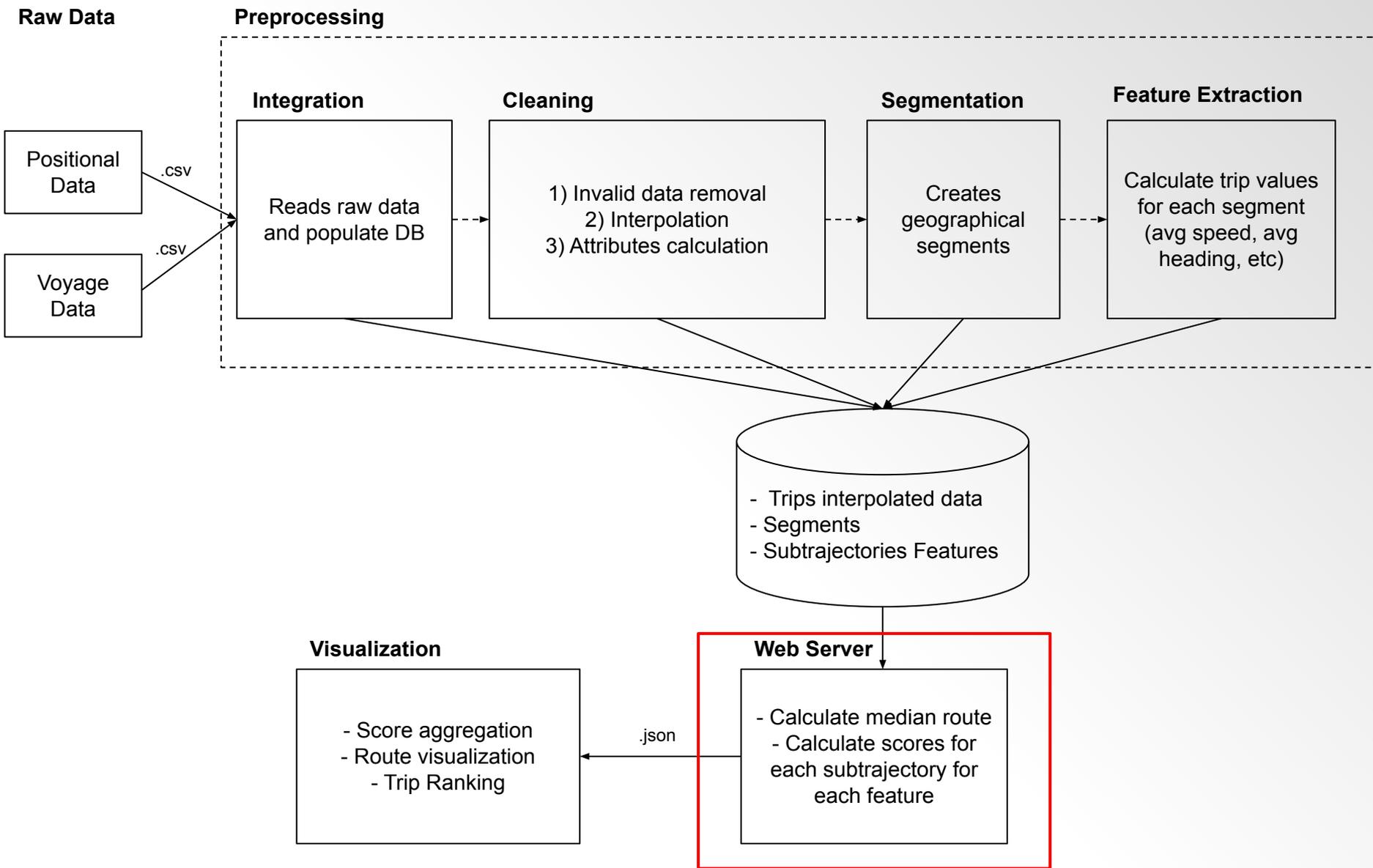
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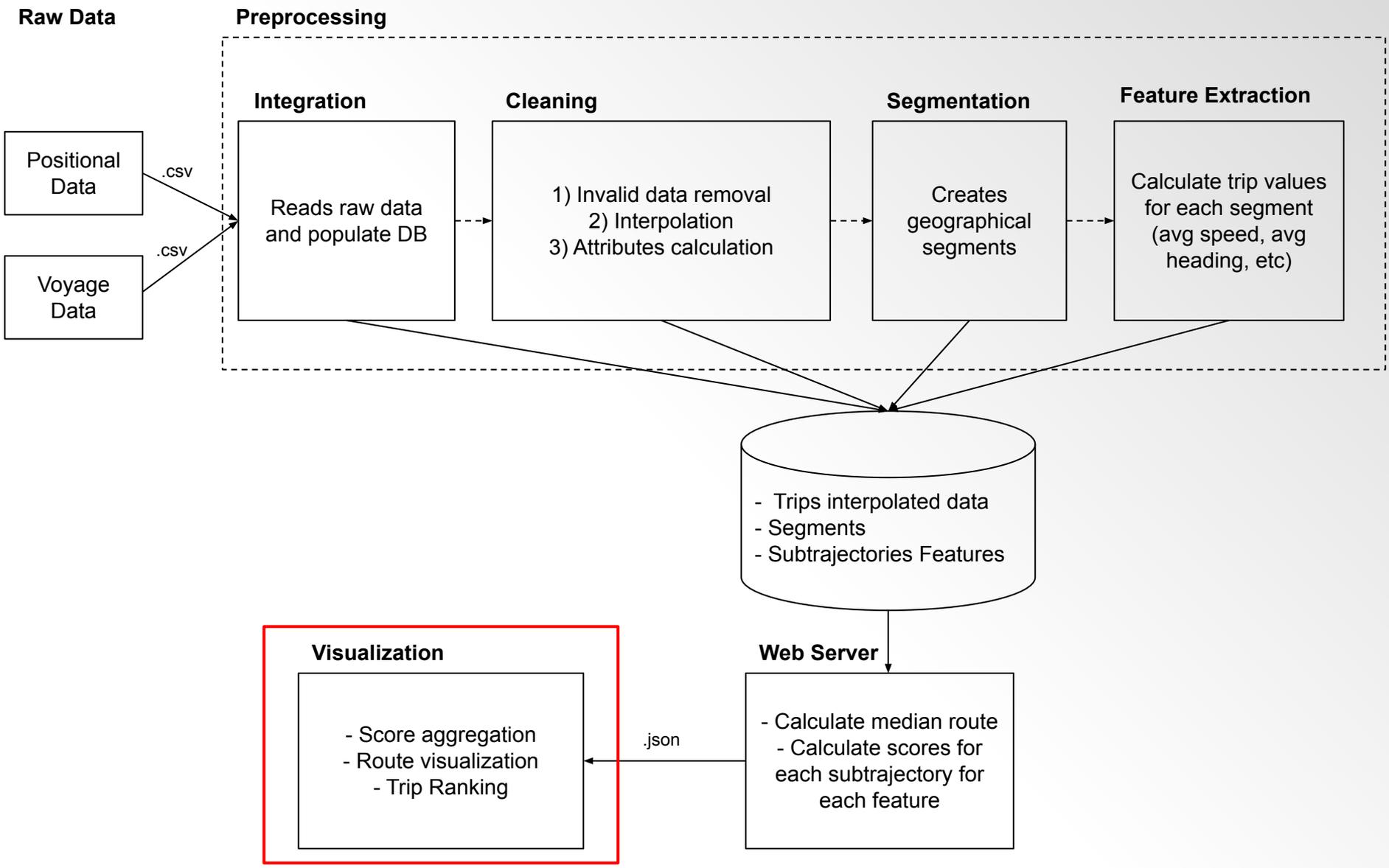












# Demo



# Trip Outlier Scoring Tool

Tutorial

## Score computation

Select the segments you want to use in the score computation

- Check all
- Seg\_1  Seg\_2  Seg\_3  Seg\_4  Seg\_5  Seg\_6
- Seg\_7  Seg\_8  Seg\_9  Seg\_10

Select the attributes you want to use in the score computation

- Check all
- Min sog  Avg sog  Max sog
- Distance travelled  Trip duration  Avg heading

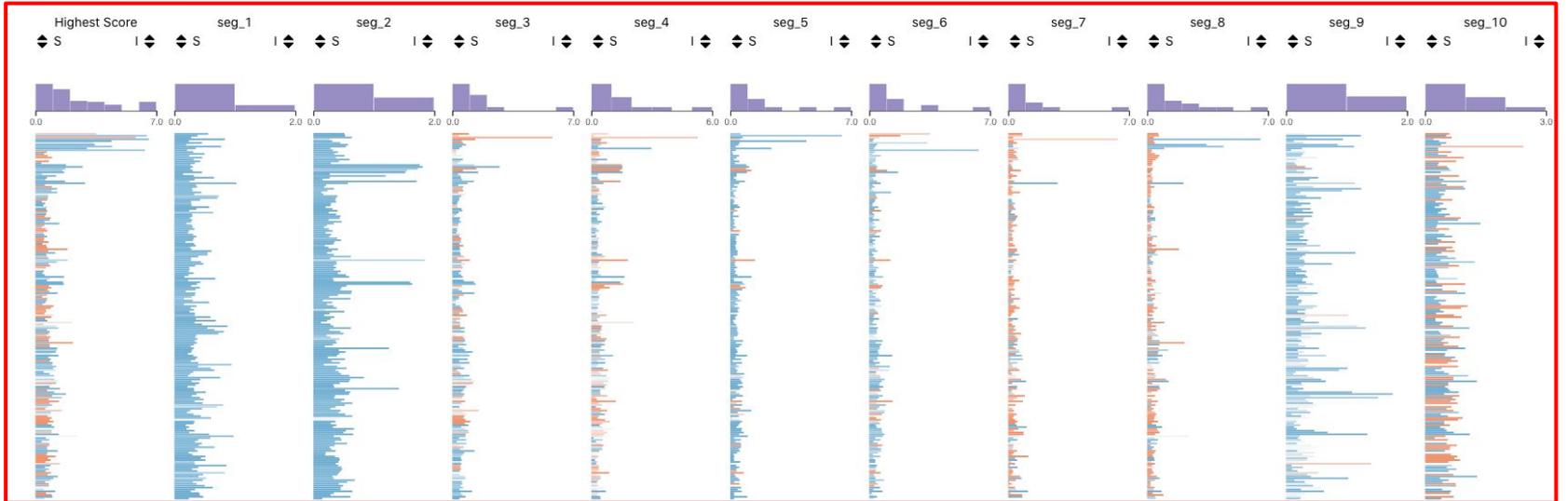


## Trip Score

Highest Score Avg Score

reset filters show filters

?



Trip Id: 339  
Rank: 5

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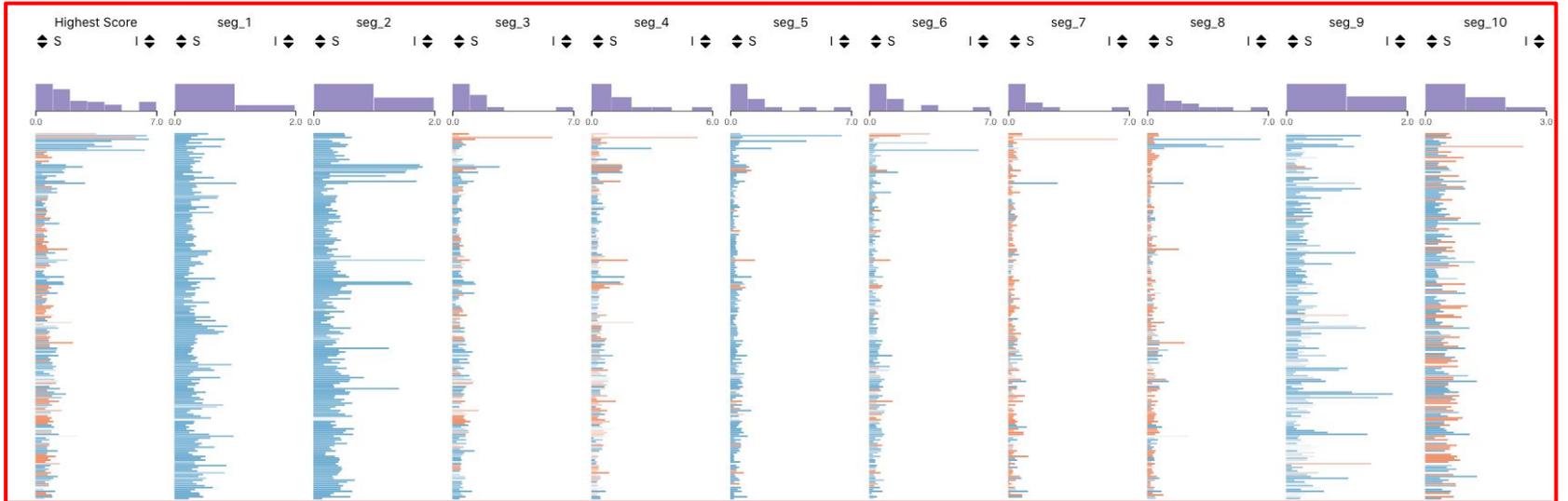


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reset filters show filters

?



Trip Id: 339  
Rank: 5

S: 4.57, I: 0%    S: 0.25, I: 0%    S: 0.32, I: 0%    S: 0.56, I: 9%    S: 0.47, I: 15%    S: 4.57, I: 0%    S: 0.22, I: 12%    S: 0.33, I: 97%    S: 0.40, I: 97%    S: 0.13, I: 15%    S: 0.36, I: 0%

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reset filters show filters

seg\_1 seg\_2 seg\_3 seg\_4 seg\_5 seg\_6 seg\_7 seg\_8 seg\_9 seg\_10



Trip Id: 339 Rank: 5

Segment	Score (S)	Interpolation (I)
seg_1	4.57	0%
seg_2	0.25	0%
seg_3	0.32	0%
seg_4	0.56	9%
seg_5	0.47	15%
seg_6	4.57	0%
seg_7	0.22	12%
seg_8	0.33	97%
seg_9	0.40	97%
seg_10	0.13	15%

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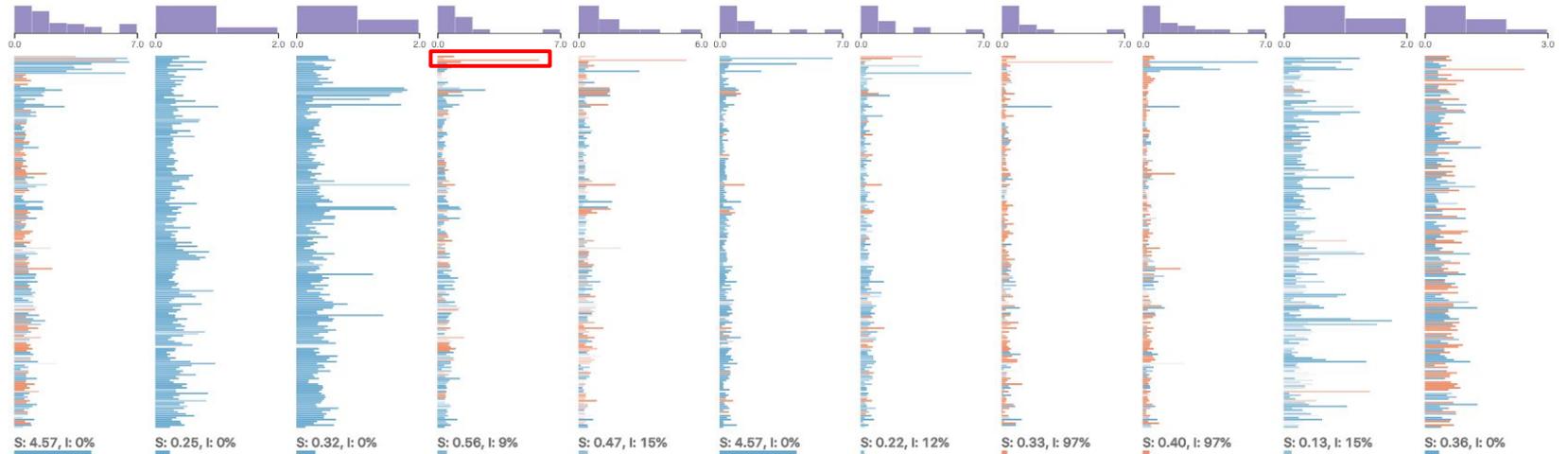


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reset filters show filters

seg\_1 seg\_2 seg\_3 seg\_4 seg\_5 seg\_6 seg\_7 seg\_8 seg\_9 seg\_10



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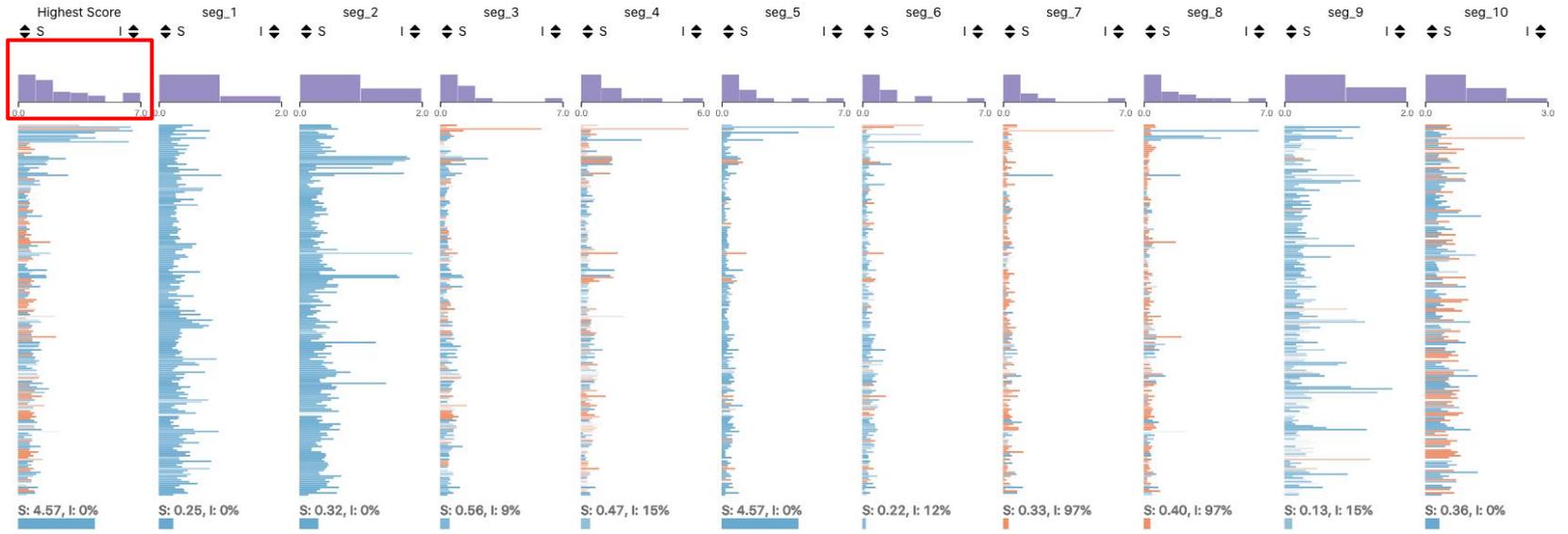
- Check all
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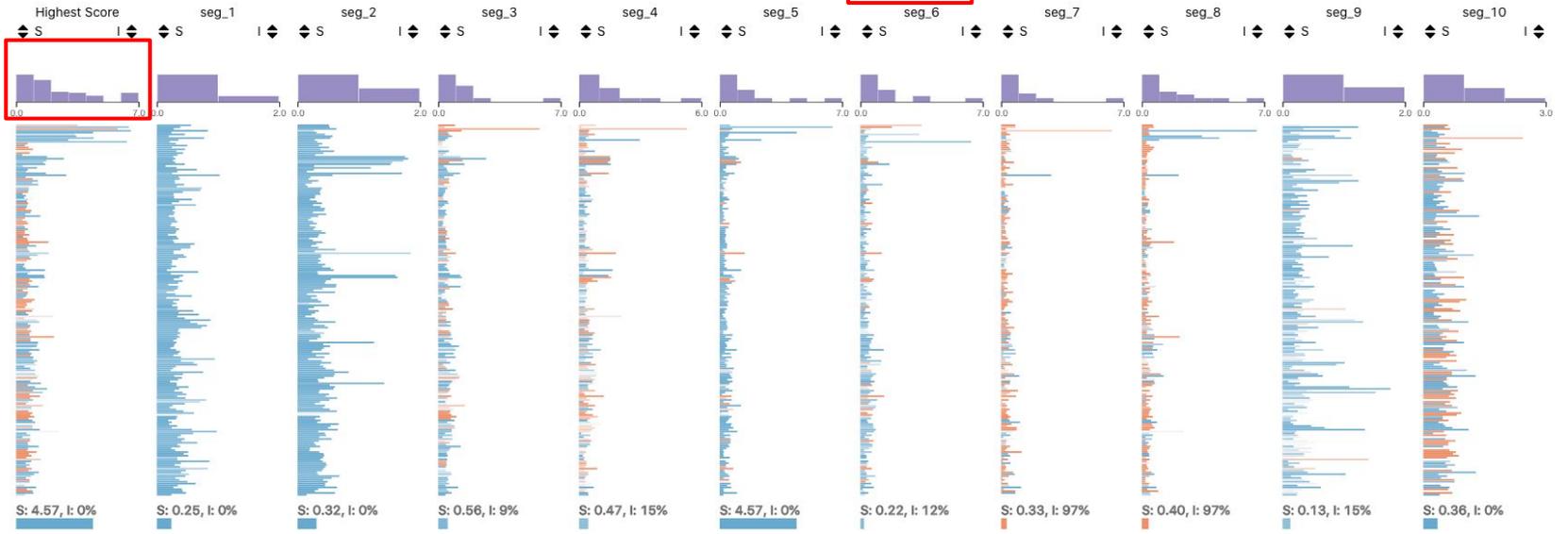


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reset filters

show filters



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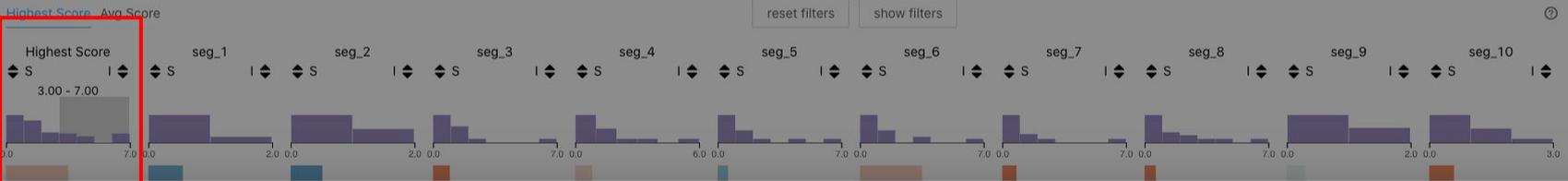
- Check all
- Seg\_1  Seg\_2  Seg\_3  Seg\_4  Seg\_5  Seg\_6
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- Distance travelled  Trip duration  Avg heading



## Trip Score



## Filters

3.0]	Min									
Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max

Update Filters

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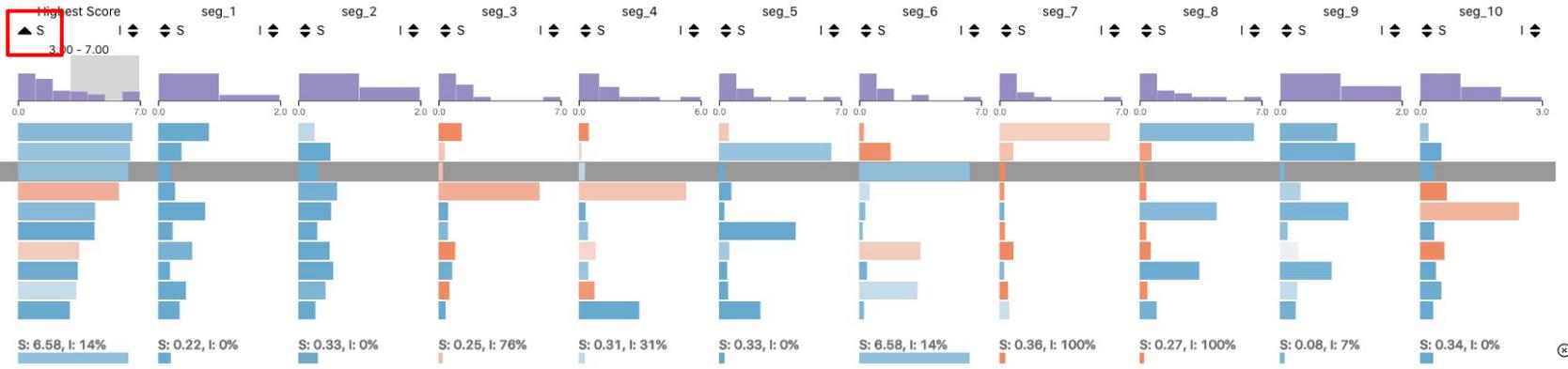
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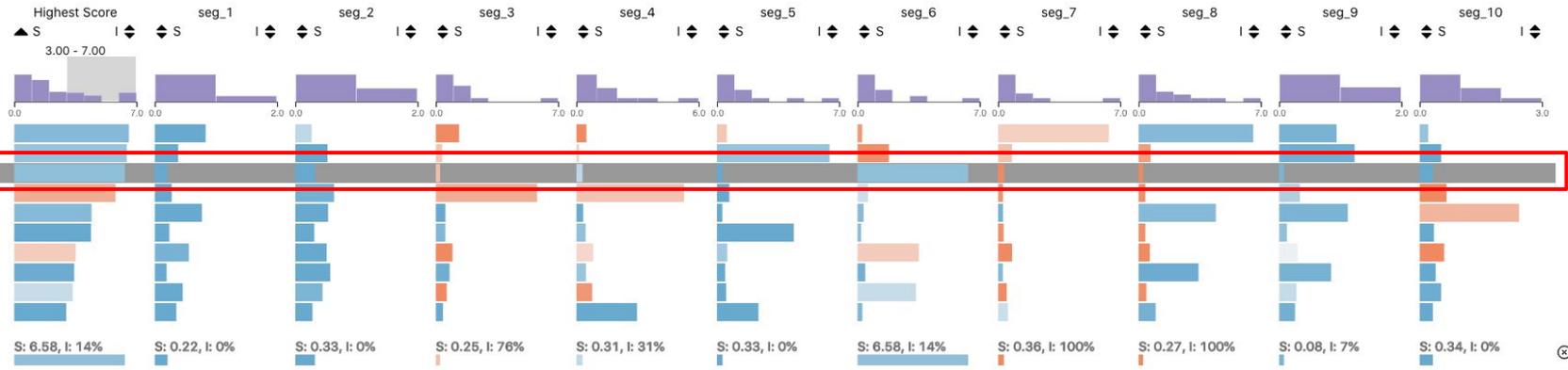
- Check all
- Min sog  Avg sog  Max sog
- Distance travelled  Trip duration  Avg heading



## Trip Score

Highest Score Avg Score

reset filters show filters



Trip Id: 1059  
Rank: 3

# Trip Outlier Scoring Tool

Tutorial

## Score computation

Select the segments you want to use in the score computation

- Check all
- Seg\_1  Seg\_2  Seg\_3  Seg\_4  Seg\_5  Seg\_6
- Seg\_7  Seg\_8  Seg\_9  Seg\_10

Select the attributes you want to use in the score computation

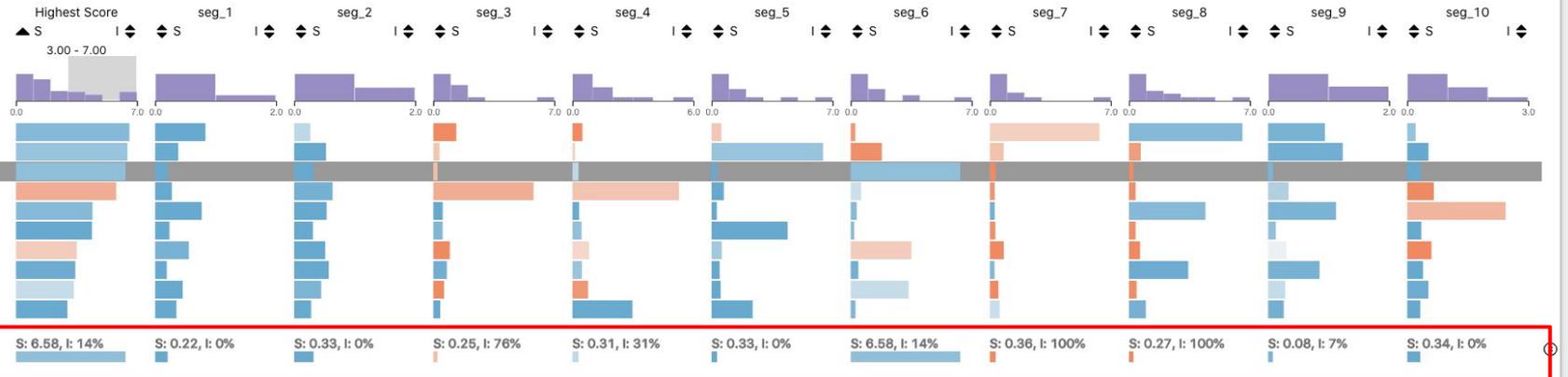
- Check all
- Min sog  Avg sog  Max sog
- Distance travelled  Trip duration  Avg heading



## Trip Score

Highest Score Avg Score

reset filters show filters



# Trip Outlier Scoring Tool

Tutorial

## Score computation

Select the segments you want to use in the score computation

- Check all
- Seg\_1  Seg\_2  Seg\_3  Seg\_4  Seg\_5  Seg\_6
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Select the attributes you want to use in the score computation

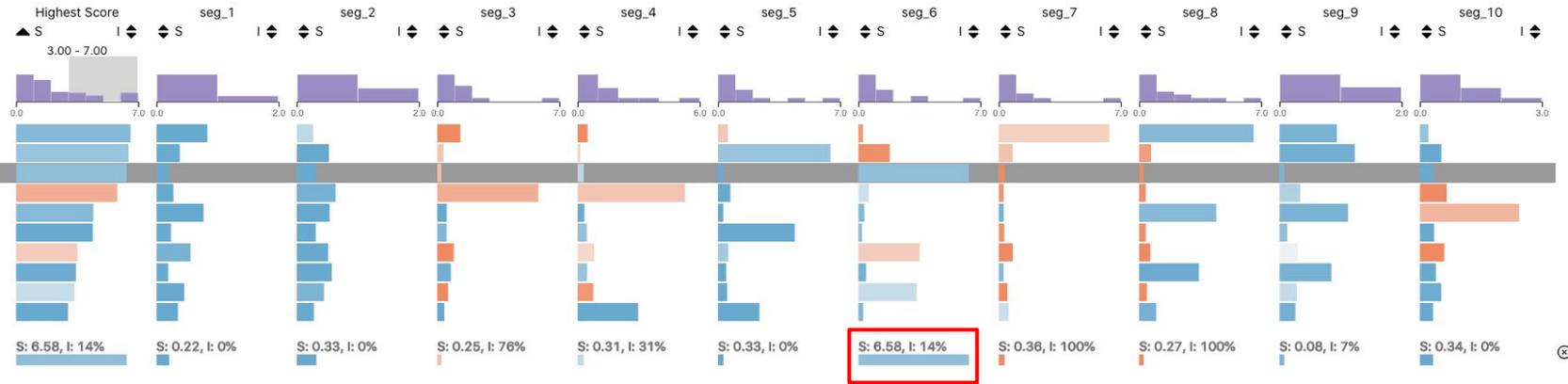
- Check all
- Min sog  Avg sog  Max sog
- Distance travelled  Trip duration  Avg heading



## Trip Score

Highest Score Avg Score

reset filters show filters



# Trip Outlier Scoring Tool

Tutorial

## Score computation

Select the segments you want to use in the score computation

- Check all
- Seg\_1  Seg\_2  Seg\_3  Seg\_4  Seg\_5  Seg\_6
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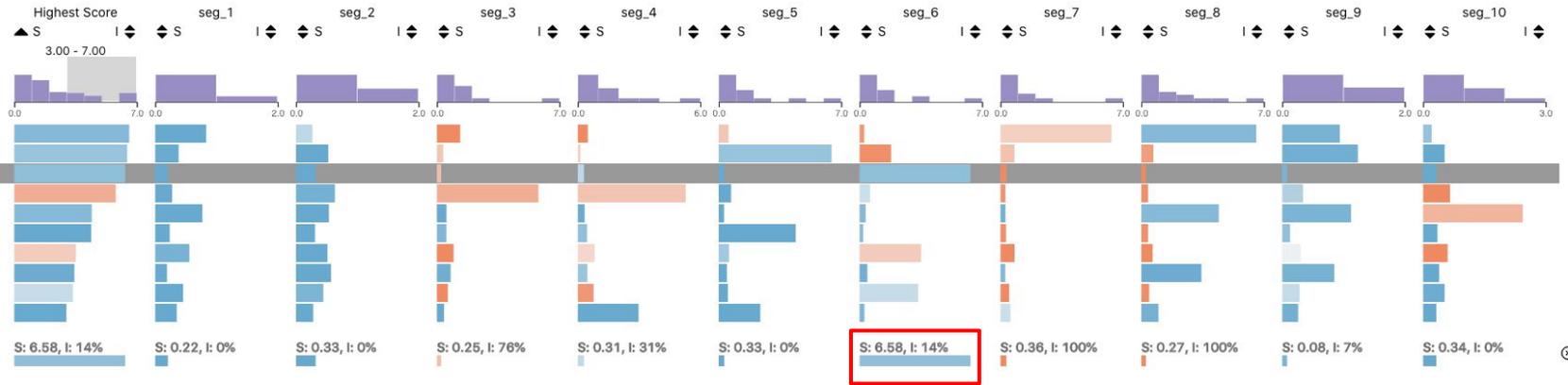
- Check all
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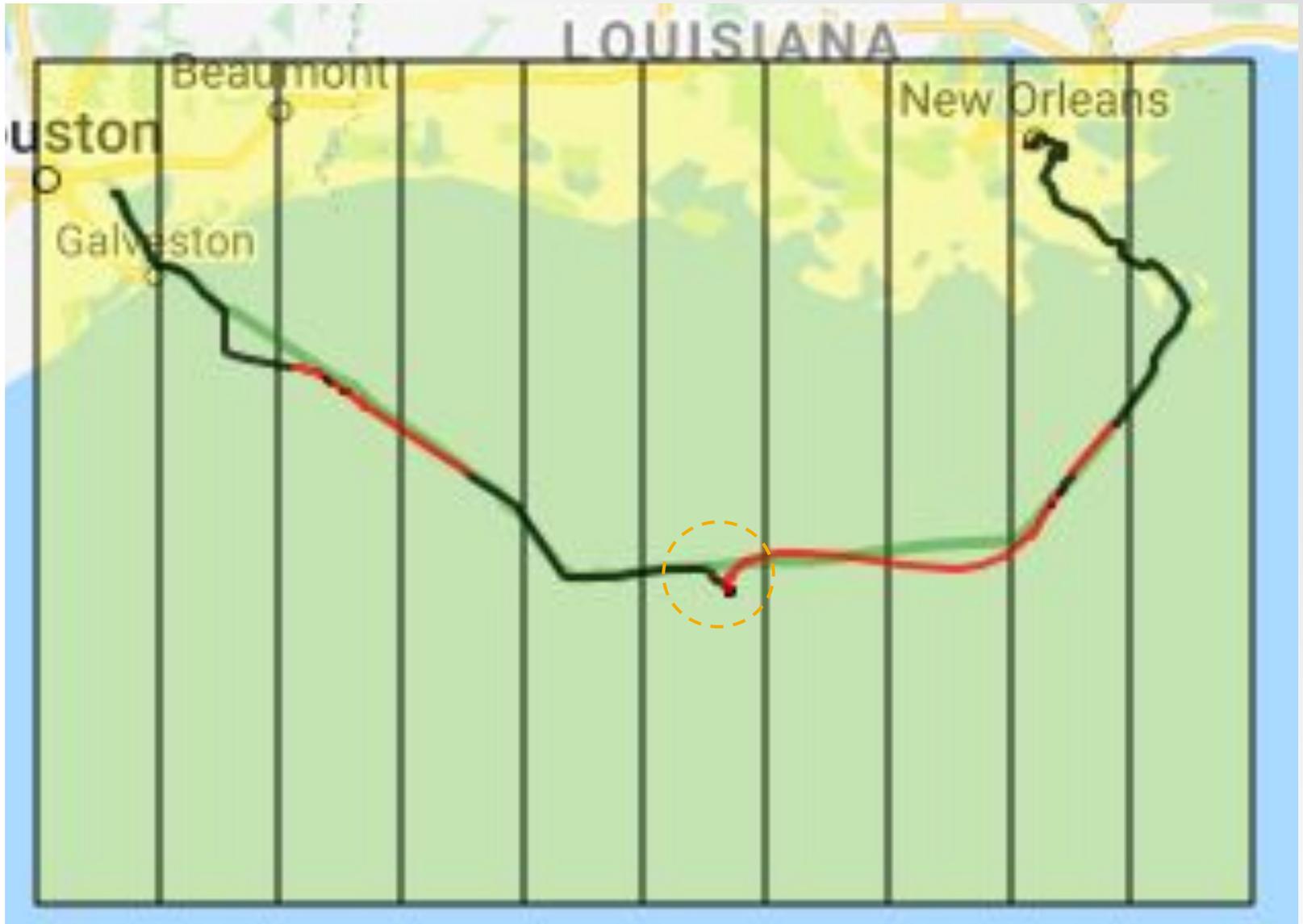
## Trip Score

Highest Score Avg Score

reset filters show filters



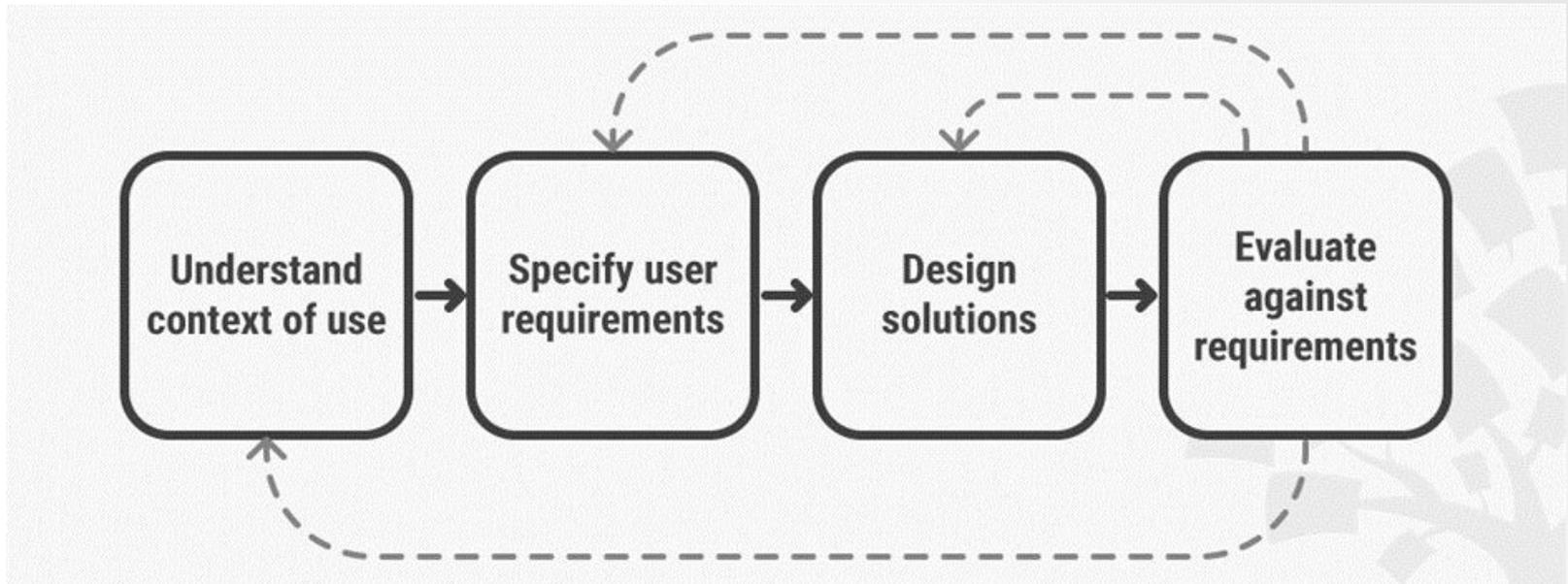
Trip Id: 1059  
Rank: 3



# Discussion

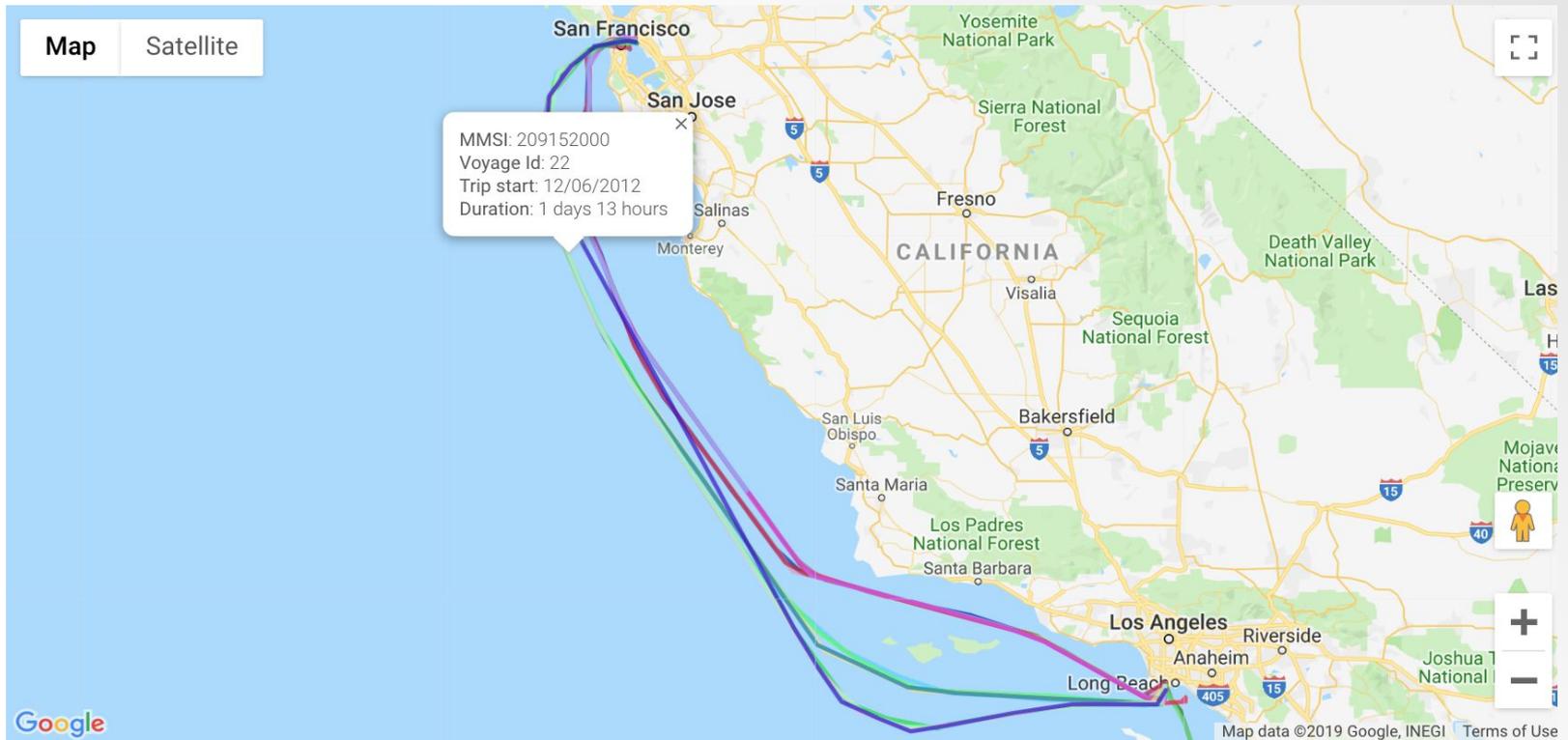
# Discussion

- Study research



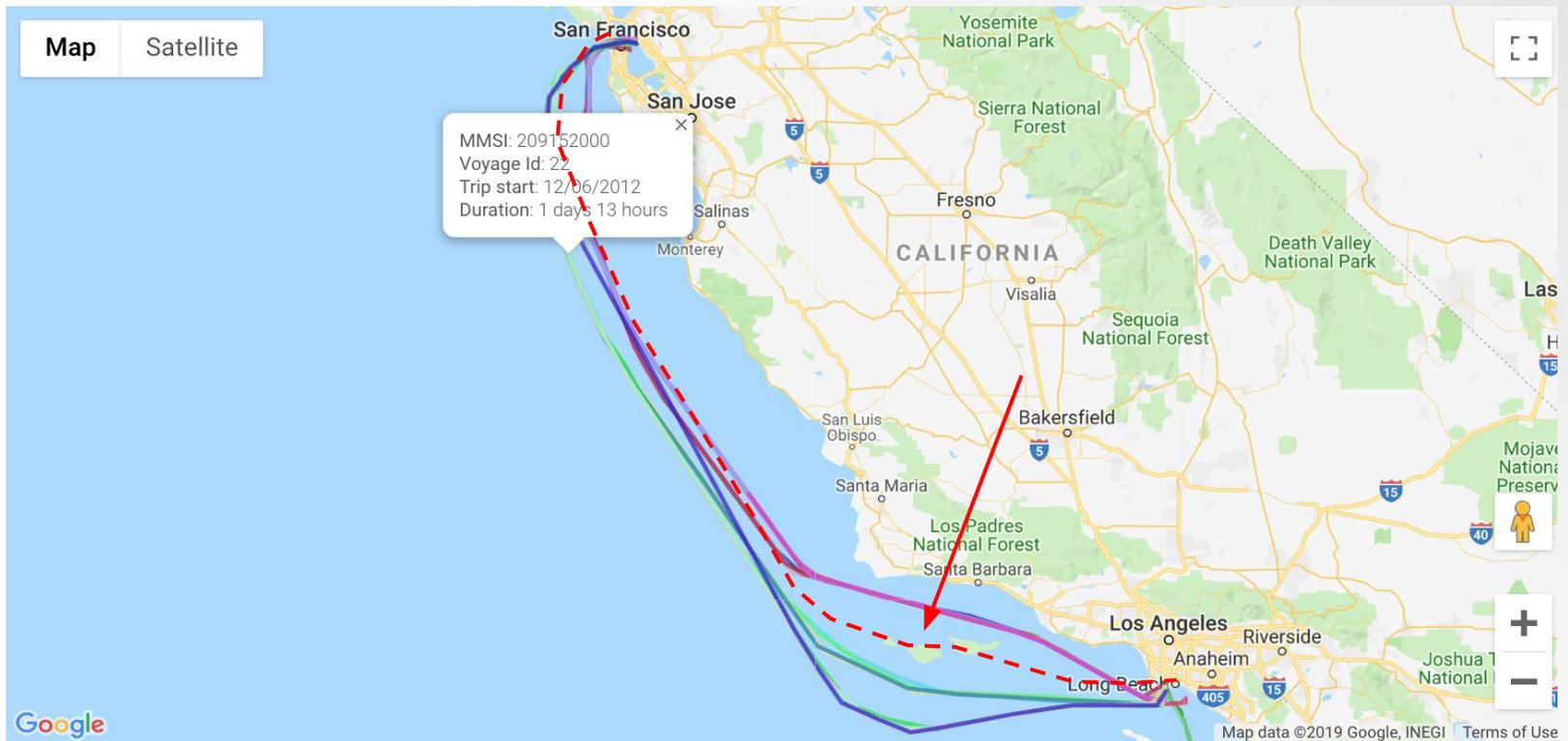
# Discussion

- Score computation



# Discussion

- Mean trajectory



# Discussion

- Segmentation

VesselRank

### Segmenting creation

Creating segments between port A and port B

Segmentation Name:

### Segments

1

2

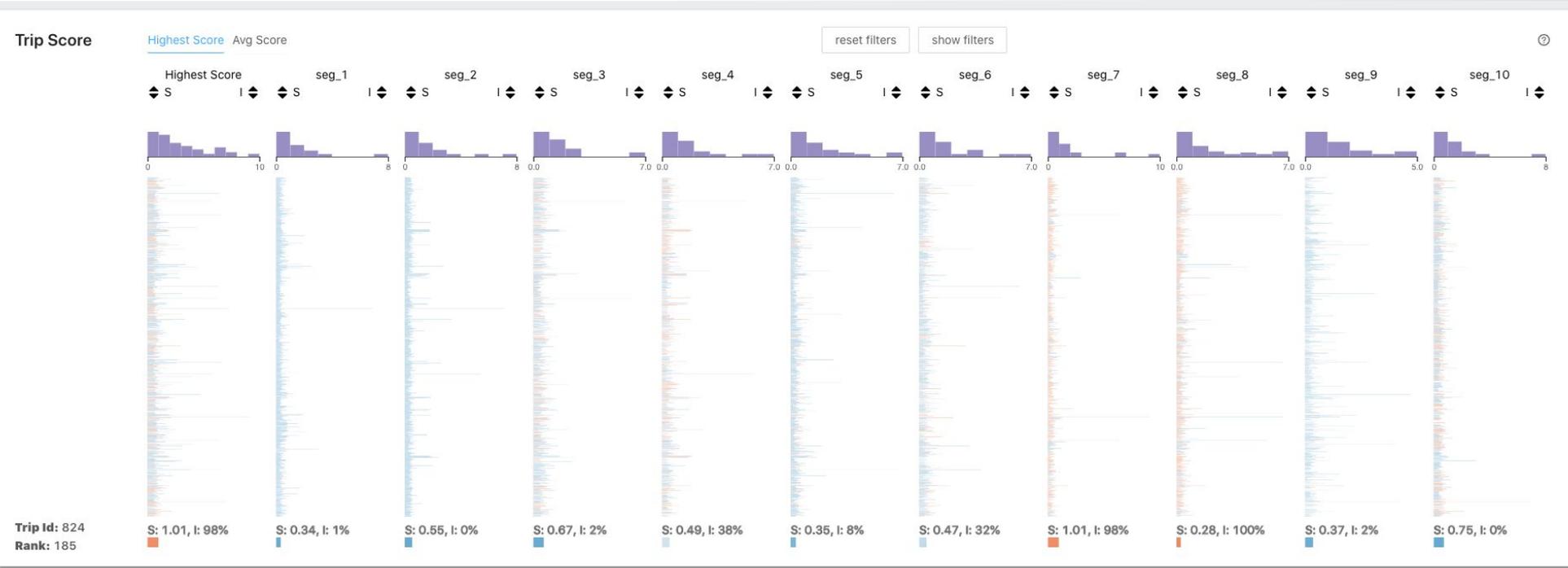
# Discussion

- Interpolation



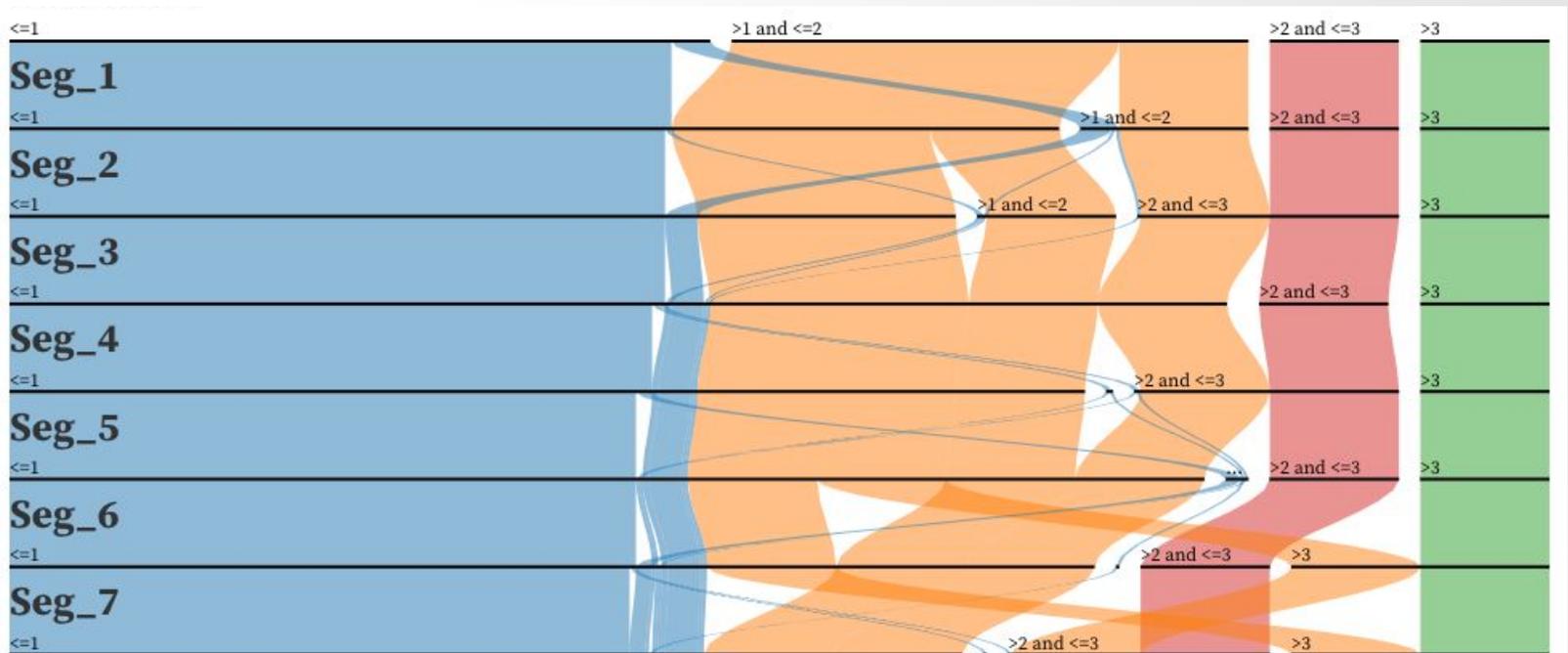
# Discussion

- Visual Clutter



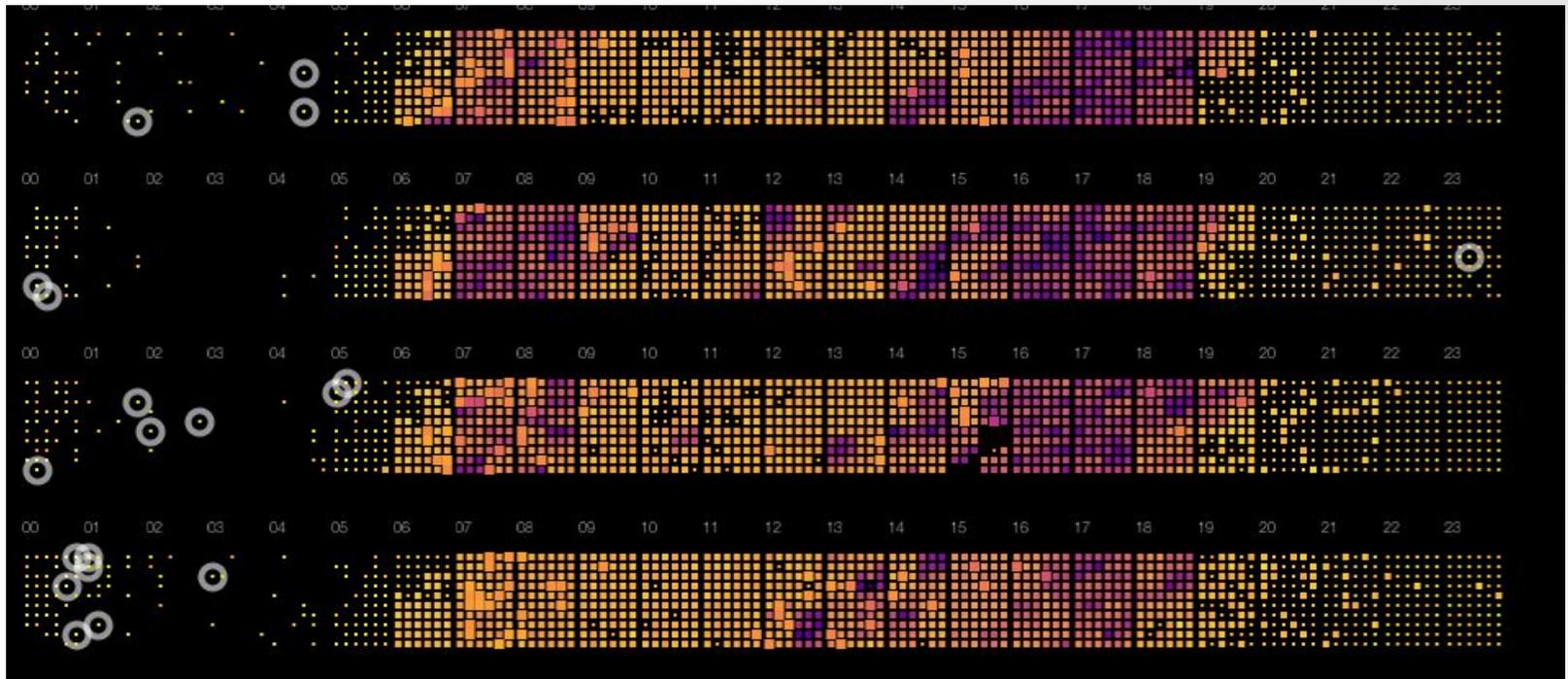
# Discussion

- Visual Clutter



# Discussion

- Visual Clutter



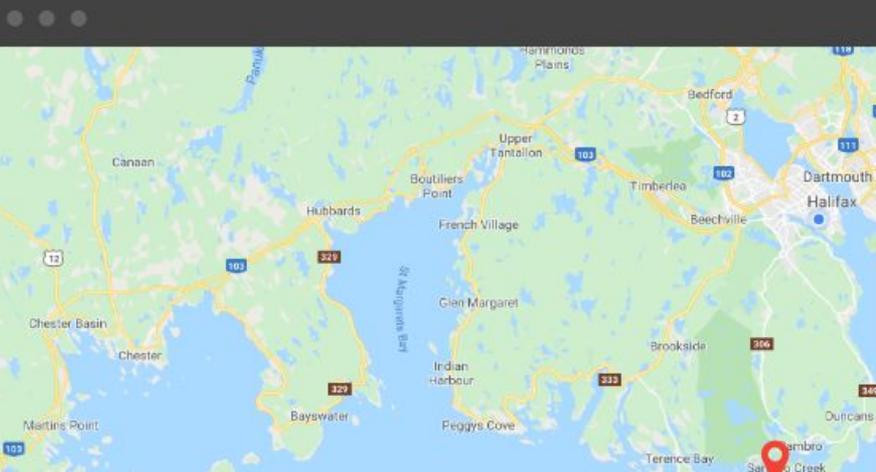
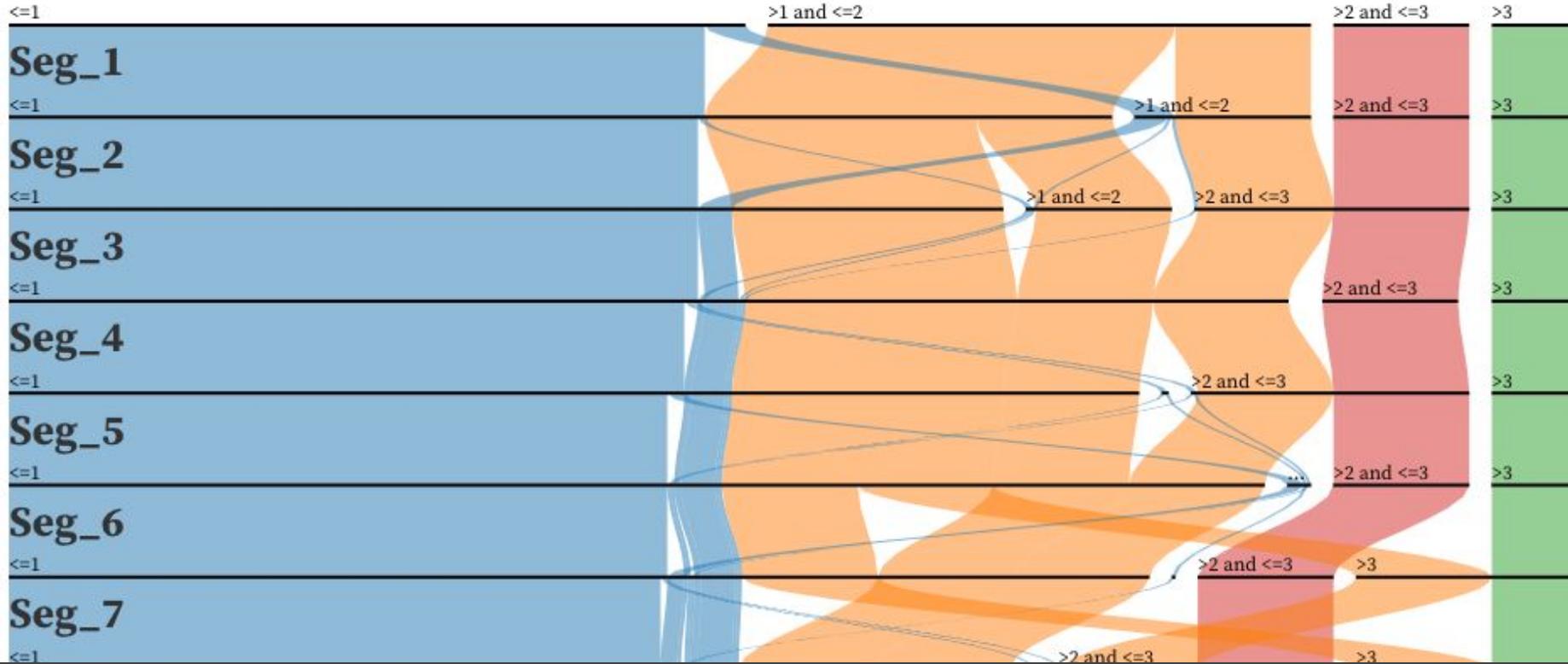
# Conclusion

**Thank you!**

# Discussion

- Evaluation
- Single distribution
- Segmentation
- Mean trajectory
- Clutter
- Exploration
- Interpolation

# totalScore



VesselRank

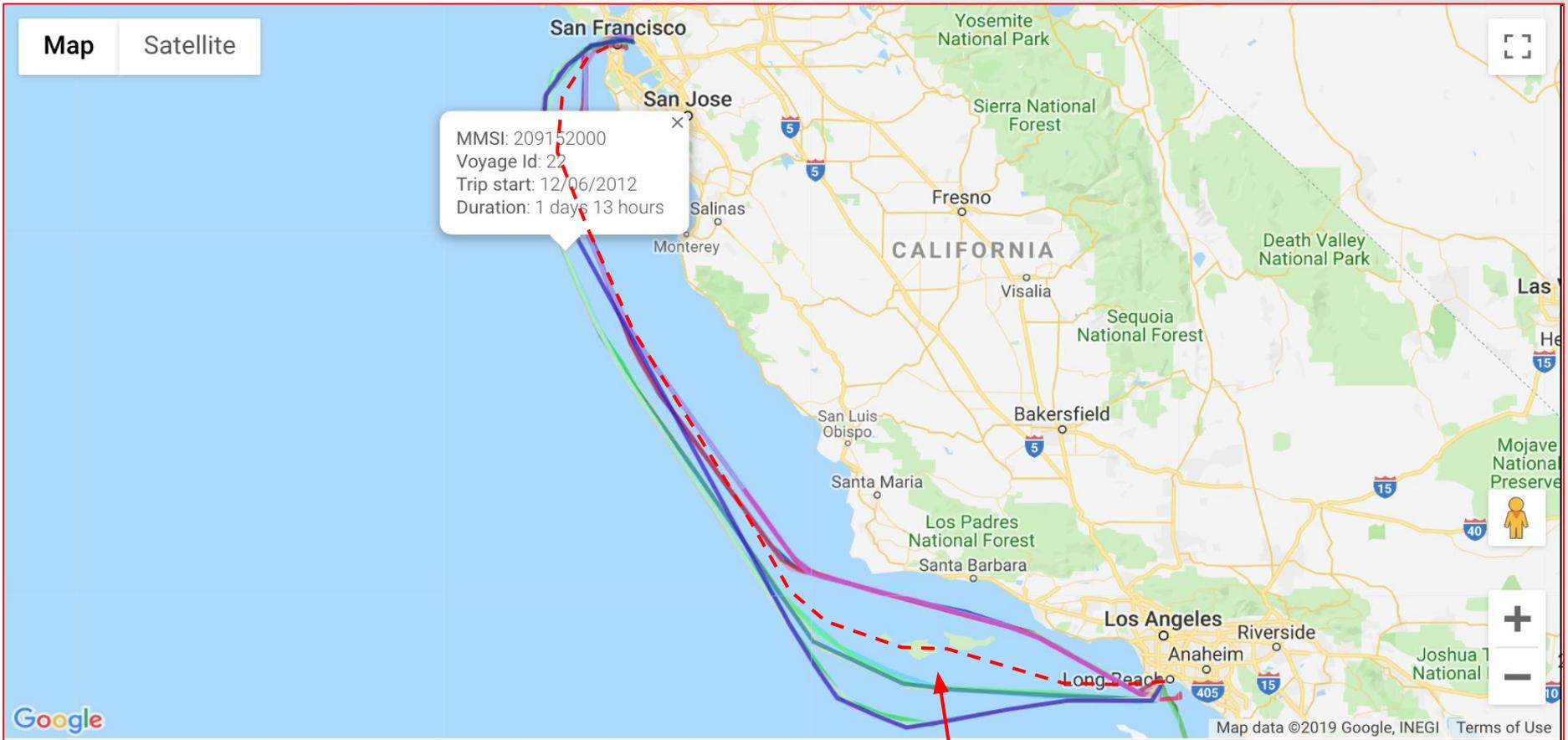
## Segmenting creation

Creating segments between port A and port B

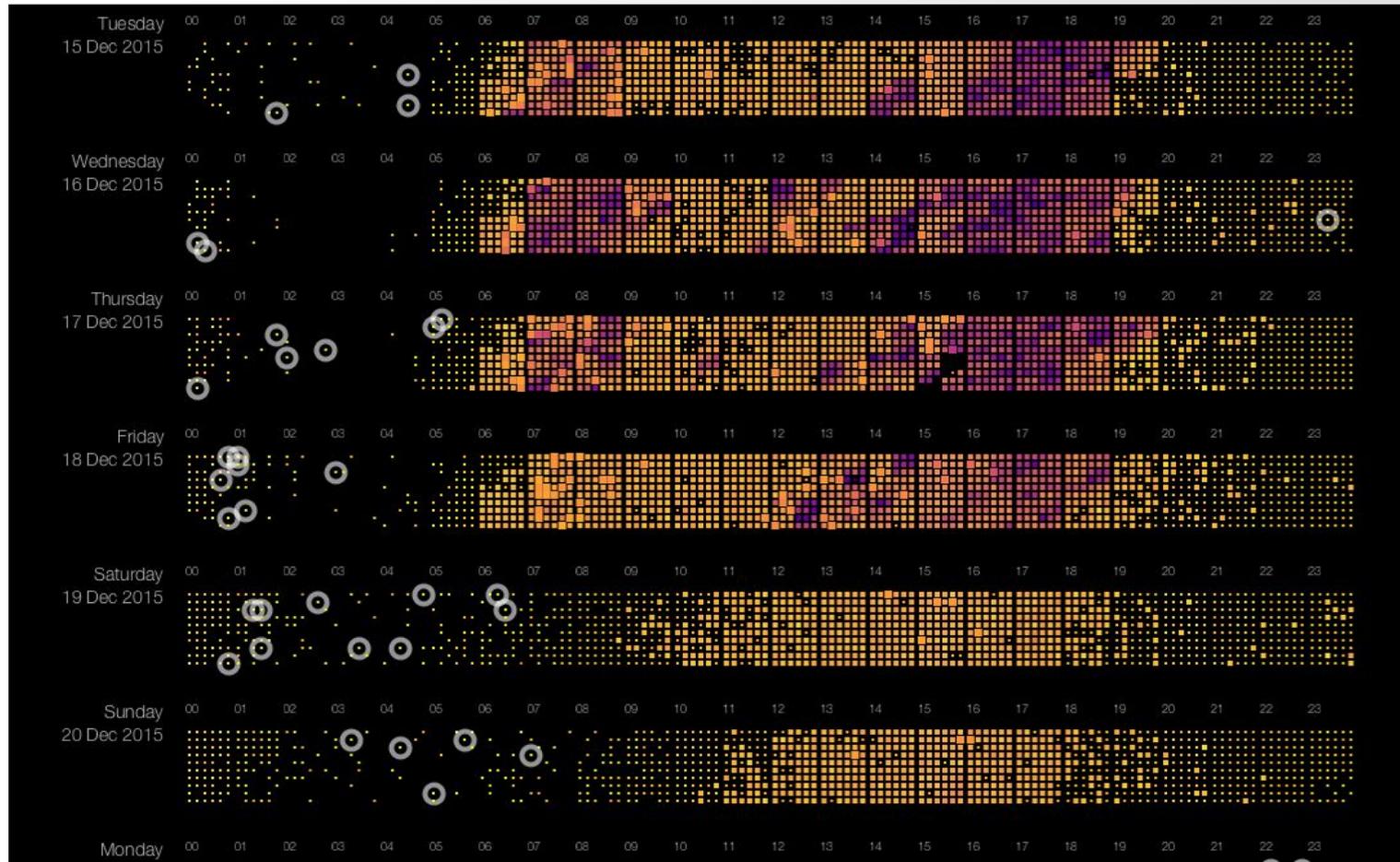
Segmentation Name:

## Segments

- 1
- 2







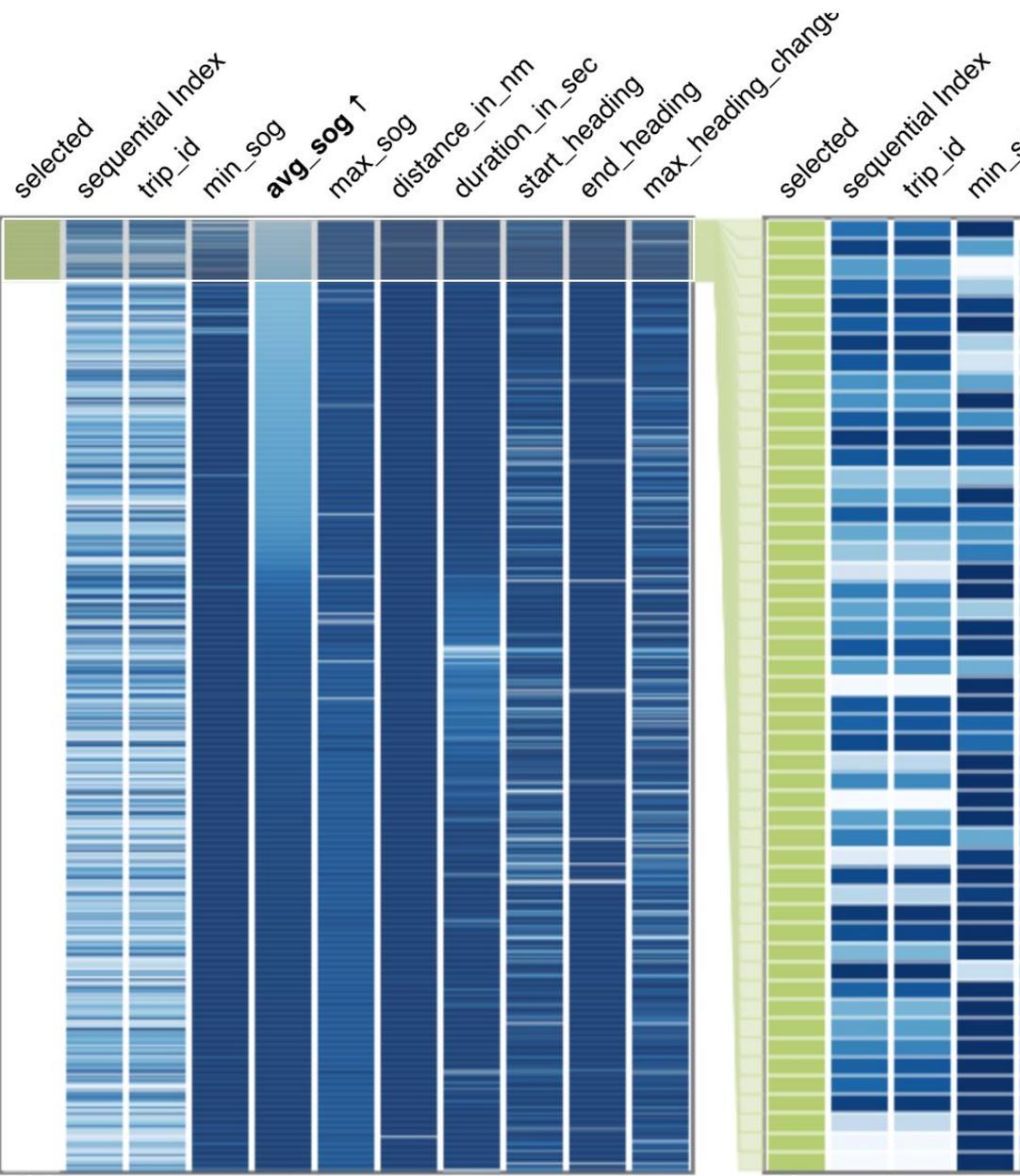
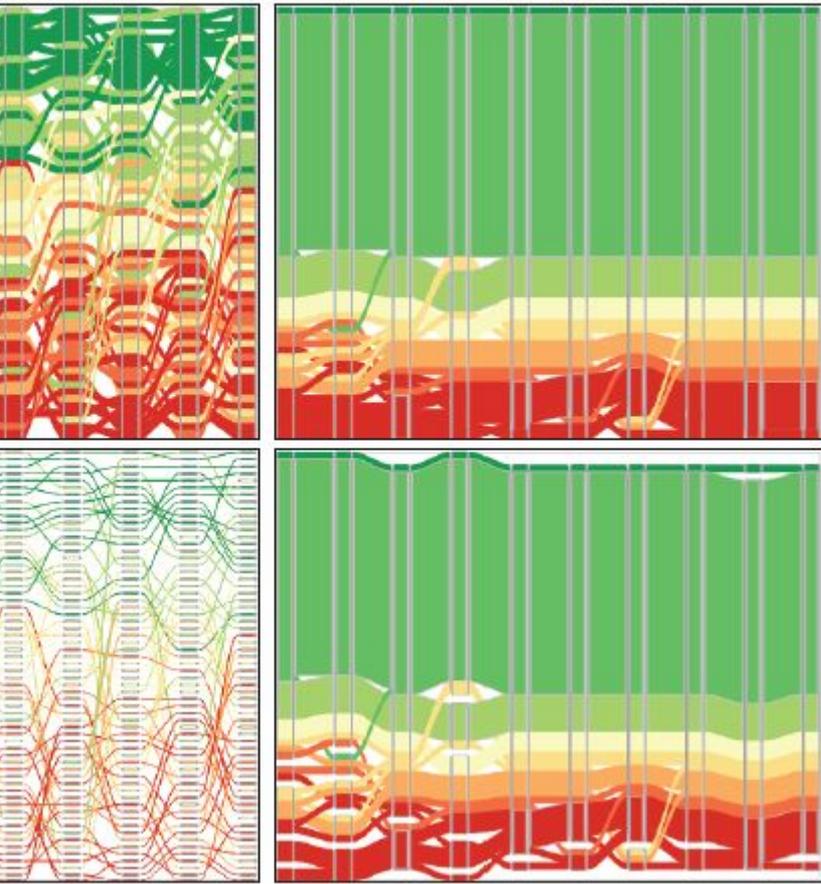
Attribute width

Navio height

30

min = 0 s

Threshold  $D_{min} = 8$  s



766

50

⊗ avg\_sog range including 0 to 0.

