

A Framework for Local Outlier Detection from Spatio-Temporal Trajectory Datasets

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Motivation

- Improve data quality, enhance the performance of the predictive modeling

eg. NOAA Active Region associated with Solar Flare Prediction.

- Detect rarely occurring, but highly impactful extreme events.

eg. When a Coronal Mass Ejections (CME) strikes Earth's atmosphere which can cause a temporary disturbance of the Earth's magnetic field.

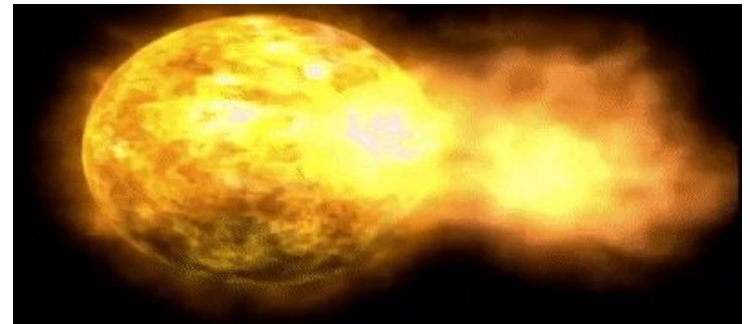
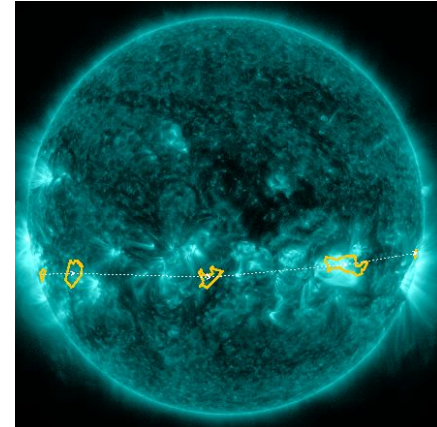
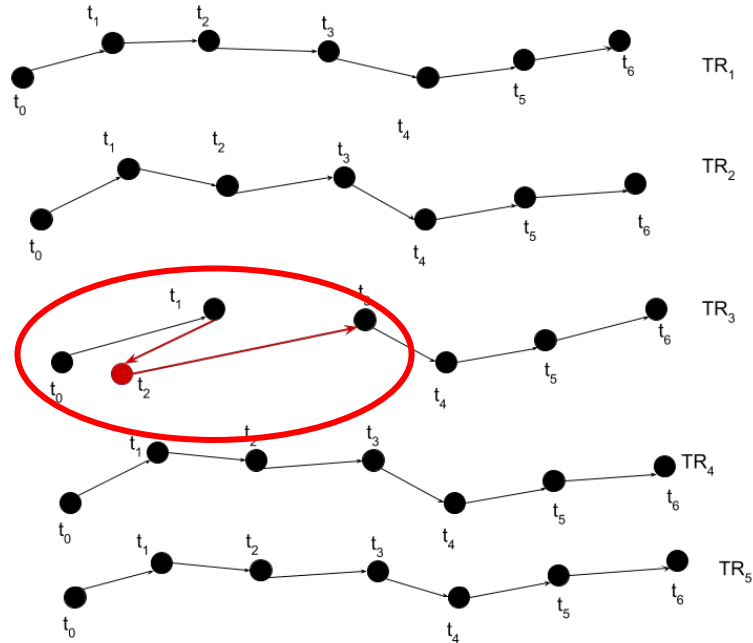


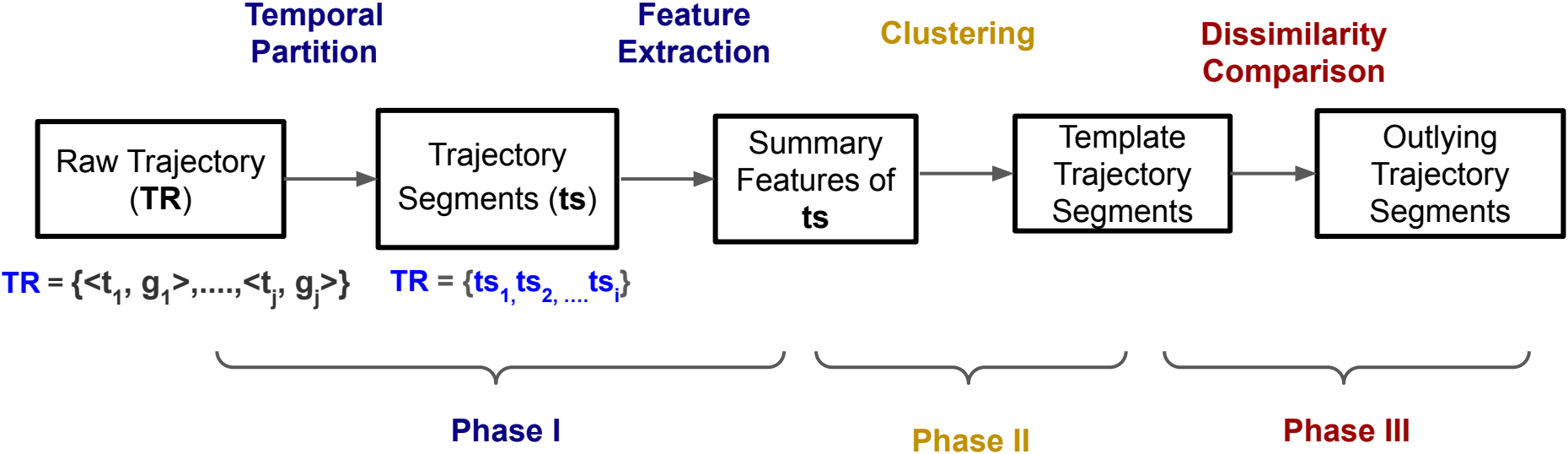
Image Credit: NASA/Walt Feimer

Outlying Trajectory Segments

Goal: Find outlying trajectory segments which are significantly different from the rest of the trajectory segments in the datasets based on the summary spatio-temporal feature of trajectory segments.



Local Outlier Detection Framework



Trajectory of NOAA Active Region

4,795 NOAA Active Region trajectories from 1996 to 2019.

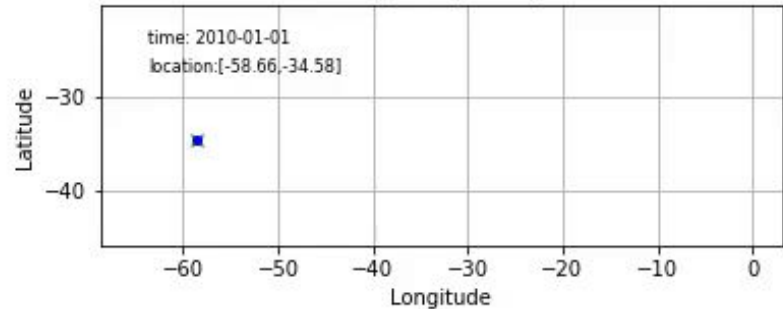
Sampling interval:

NOAA record timestamp

- Every 24 hours
- Periodic Sampling Interval

Geometry:

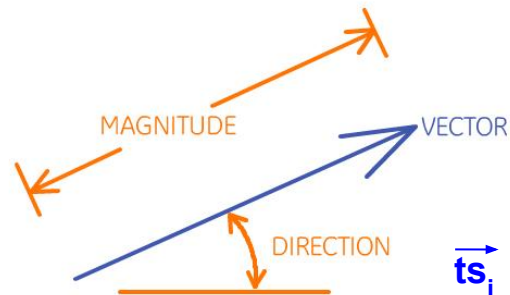
Heliographic Longitude and Latitude.



Partition Strategy and Feature Selection

Parameter Setting

- $\Delta T = 24$ hours, $n=1$
- Each ts contains two $\langle t_j, g_j \rangle$ time-geometry pairs.
- 45,319 $\langle t_j, g_j \rangle$ pairs, and generate 40,758 ts
- Cluster number $K = 3$



Descriptive Feature of Trajectory Segment

- Longitude displacement
- Latitude displacement
- Displacement Vector Magnitude
- Displacement Vector Direction

$$ts_i.x_{end} - ts_i.x_{start}$$

$$ts_i.y_{end} - ts_i.y_{start}$$

$$\| \vec{ts}_i \|$$

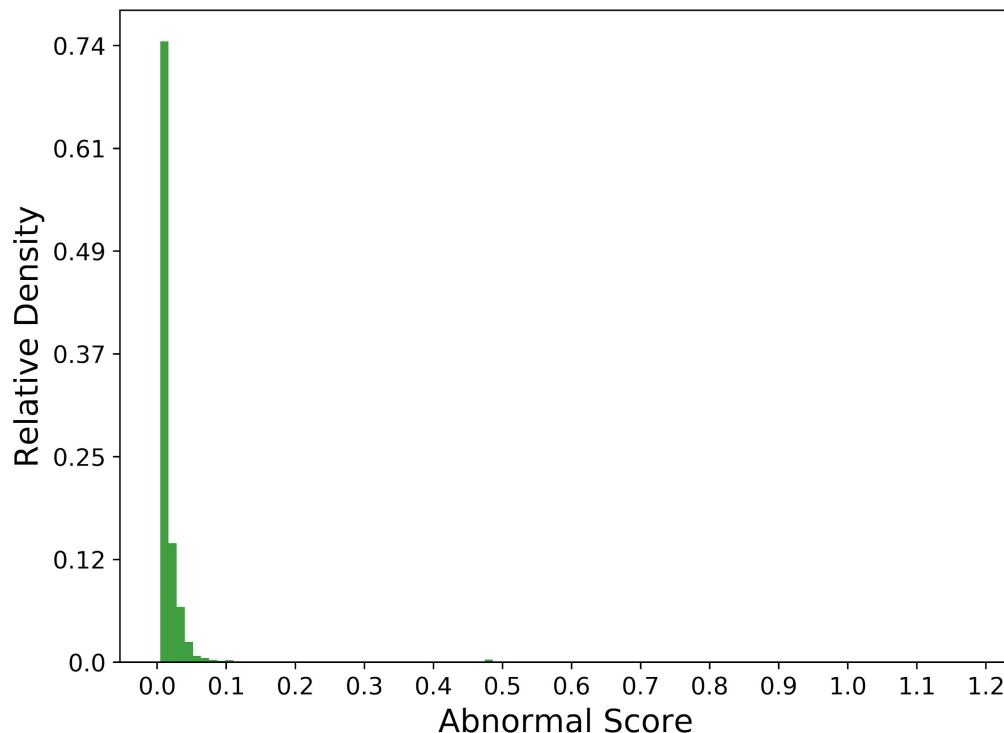
$$\tan^{-1} \left(\frac{ts_i.y_{end} - ts_i.y_{start}}{ts_i.x_{end} - ts_i.x_{start}} \right)$$

Dissimilarity Comparison using Abnormal Score

$$AB_i = \sum_{j=1}^K w_j * dist(ts_i, c_j)$$

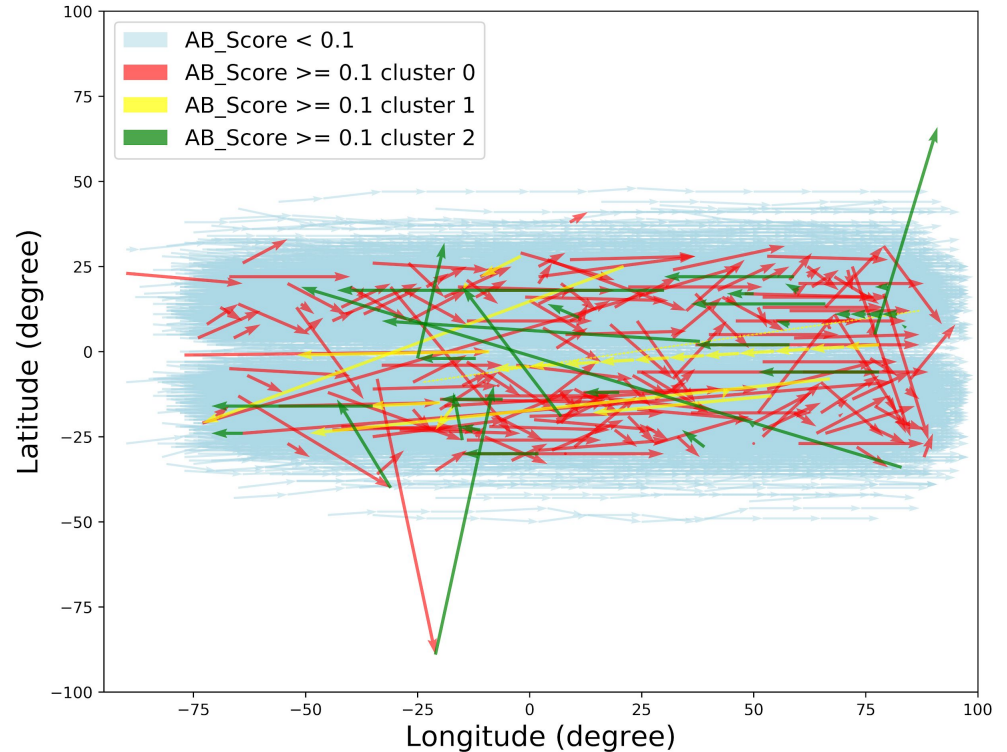
Abnormal Score Distribution:

- Set threshold equals to 0.1.
- ~1% AB score of trajectory segments greater and equal than 0.1.



Outlying trajectory segments in NOAA

- Magnitudes of normal **ts** which are uniform and move from the east to the west-limb. (i.e., average longitudinal displacement of normal **ts** is +13.33 degree and barely change latitudes and direction)
- **ots** shows the anomalous behavior in both moving directions and magnitudes.



Any Questions?

Thank You !