Big Spatial Data Management on Spark

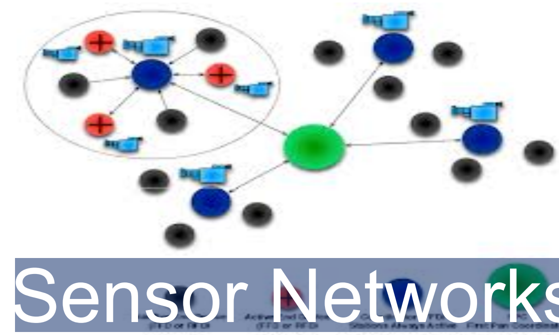
Tons of Spatial data out there…

Geotagged Microblogs

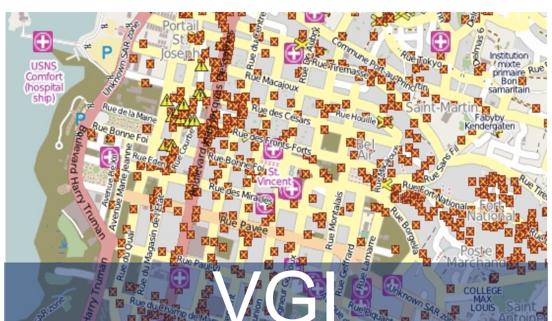
Geotagged Pictures

Medical Data

Smart Phones



Sensor Networks



VGI

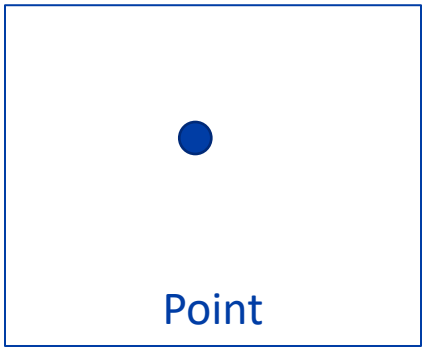
Satellite Images

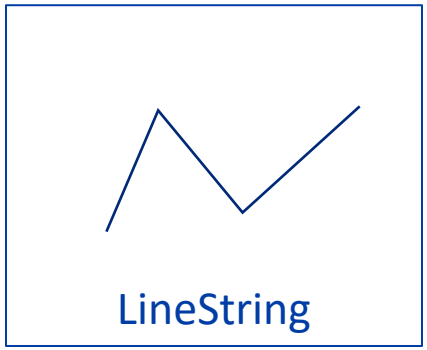
Traffic Data

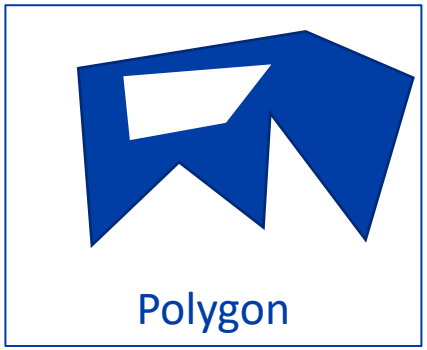
Beast

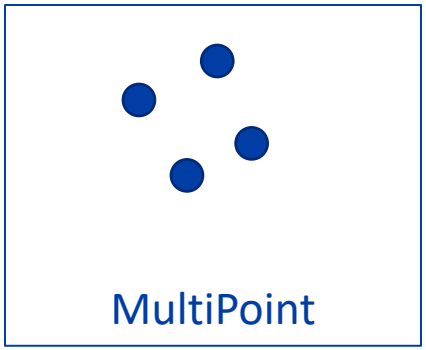
- A Spark add-on for Big Exploratory Analytics on Spatio-Temporal data
- Developed at UCR
  - You will get high-quality support ☺
- Already used in UCR-Star and other live applications

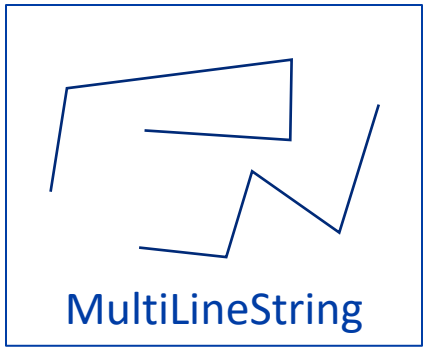
Geometry Data Types

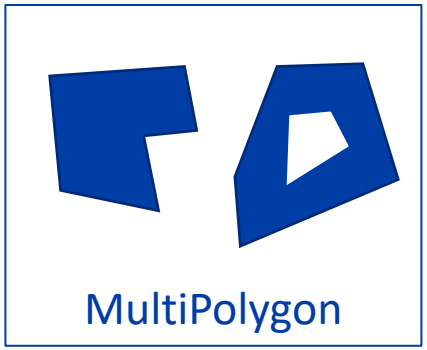


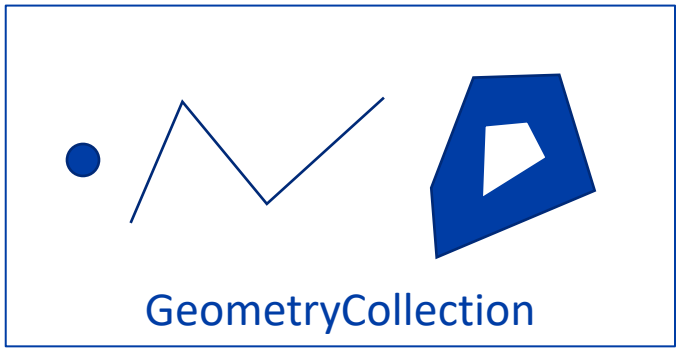




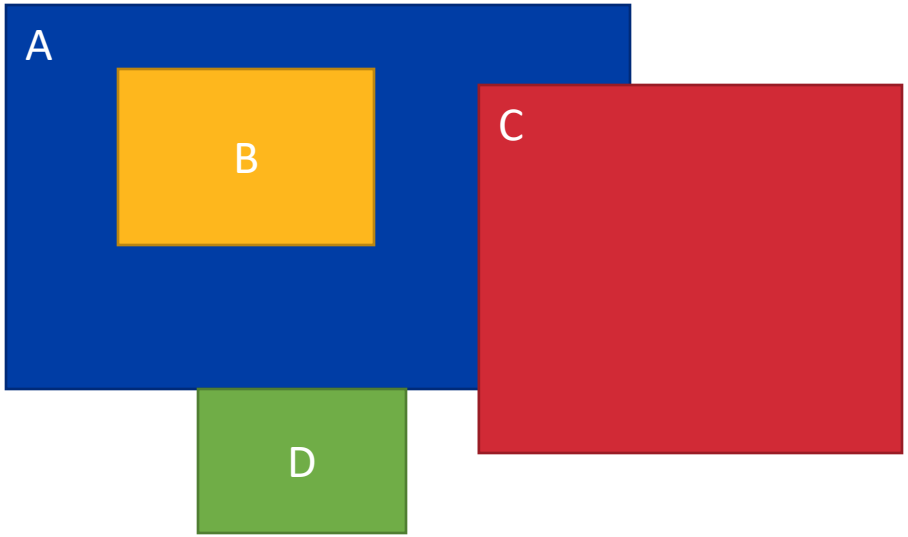








Geometry Predicates



A Contains B

A Overlaps C

B Disjoint C

A Touches D

Geometric Analysis Functions

- Create Point, LineString, …
- Intersection, Union, Difference
- Area, Length
- Centroid, Convex Hull

Spatial Feature (IFeature)

Feature = Geometry + Other Attributes

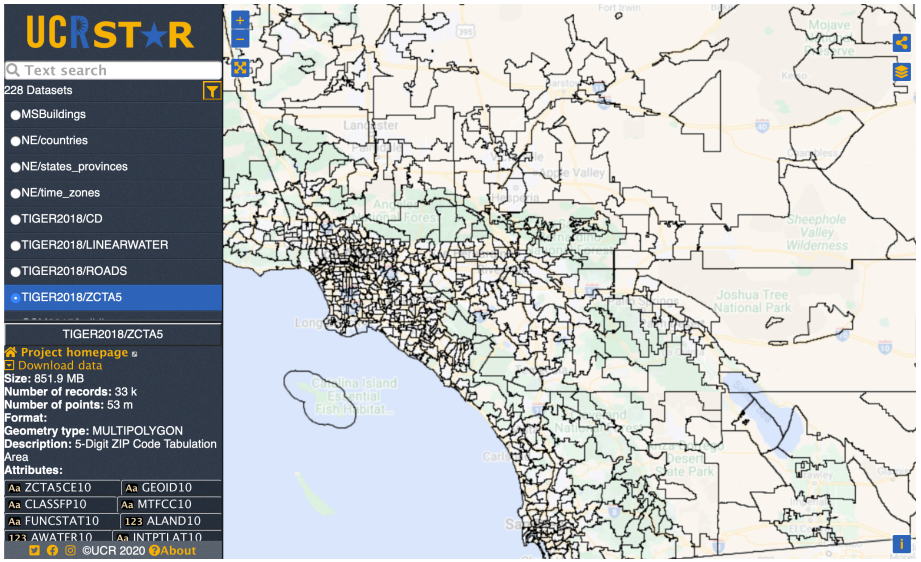
- Example
  - Road(Geometry, Name, Speed Limit)
  - State(Geometry, Name, Population)

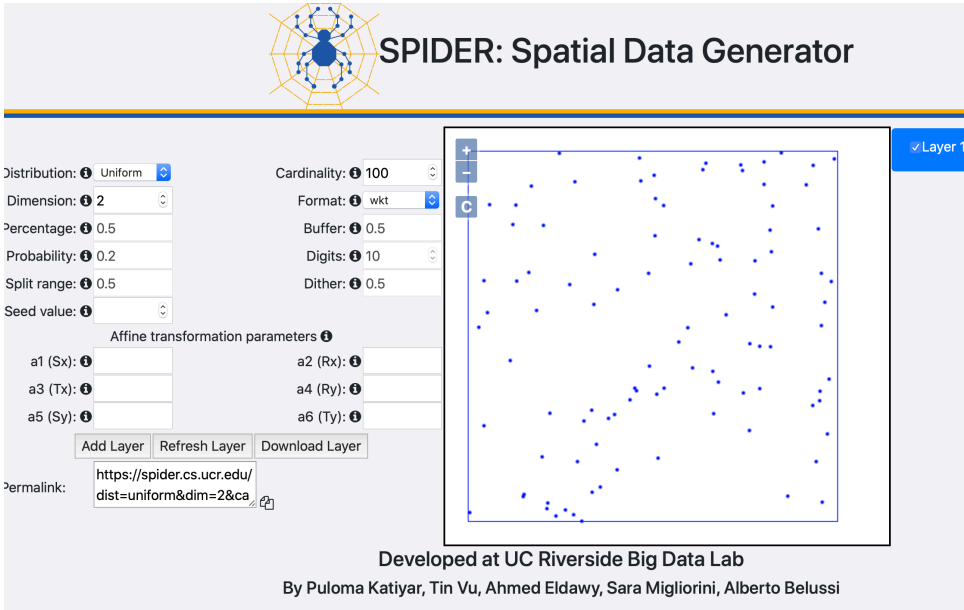
- SpatialRDD = RDD[IFeature] or JavaRDD<IFeature>

Data Source

- UCRStar.com
- 200+ datasets
- Full/subset download
- Standard formats

- Spider.cs.ucr.edu
- Still beta
- Data generator





Spatial Functions in Spark

- Data loading
- Simple manipulation
- Summarization
- Partitioning
- Range filters
- Spatial join
- Visualization

Project Setup

pom.xml

```
<dependencies>
  <dependency>
    <groupId>edu.ucr.cs.bdlab</groupId>
    <artifactId>beast-spark</artifactId>
    <version>0.8.2</version>
  </dependency>
</dependencies>
```

App.scala

```
import edu.ucr.cs.bdlab.beast._
```

Data Loading

```
// Load a shapefile
val polygons: RDD[IFeature] =
sc.shapefile("tl_2018_us_state.zip")
// Load GeoJSON file
val points = sc.geojsonFile("Tweets.geojson")

// Load points from a CSV file
val lines = sc.readCSVPoint("Crimes.csv",
    "Longitude", "Latitude", ',', skipHeader = true)

// Load geometries from a CSV file
val lines = sc.readWKTFile("States.csv", 0,
    '\t', skipHeader = false)
```

Simple Manipulation

```
// Calculate the area and append as a new attribute
polygons.map(f => {
  val area = f.getGeometry.getArea
  val newF = new Feature(f)
  newF.appendAttribute("area", area)
  newF
})
// Simplify the geometries into their convex hull
polygons.map(f => {
  val ch = f.getGeometry.convexHull()
  val newF = new Feature(f)
  newF.setGeometry(ch)
  newF
})
```

Summarization

```
// Calculate a simple summary for geometries
val summary: Summary = polygons.summary
println(summary)
```

```
Output


MBR: [(-179.231086, -14.601813), (179.859681,
71.439786)], size: 14807211, numFeatures: 56, numPoints:
924434, avgSideLength: [12.188812250000007,
4.276107500000001]
```

Histogram

```
// Calculate a histogram of 100 x 100
val histogram = points.uniformHistogramCount(Array(100, 100))
println(histogram.getValue(Array(0, 0), Array(40, 10)))
```

```
Output


482
```

Spatial Partitioning

```
// Partition the dataset into 100 partitions using a uniform grid partitioner
val partitionedPoints: RDD[(Int, IFeature)] =
points.partitionBy(classOf[GridPartitioner], 100)

// More balanced partitions
val partitionedPoints: RDD[(Int, IFeature)] =
points.partitionBy(classOf[RSGrovePartitioner], 100)
```

Range Filters

```
// Select the geometry of the state of California
val california: IFeature = polygons.filter(f =>
f.getAttributeValue("NAME") == "California").first()

// Filter the points that are inside the state of California
val californiaPoints =
points.rangeQuery(california.getGeometry)
println(s"Number of points in California
${californiaPoints.count()}")
```

```
Output

Number of points in California 259657
```

Spatial Join

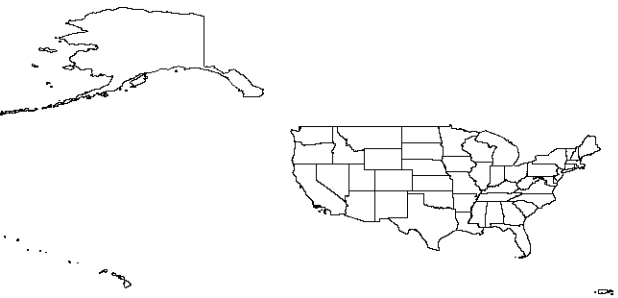
```
// Count points per state
val airportCountByState = polygons.spatialJoin(airports)
  .map(fv => (fv._1.getAttributeValue("NAME"), 1))
  .countByKey()

airportCountByState.foreach(sv =>
println(s"${sv._1}\t${sv._2}"))
```

```
Output
New Mexico      1
Connecticut1
Commonwealth of the Northern Mariana Islands      2
California    12
Nevada 3
```

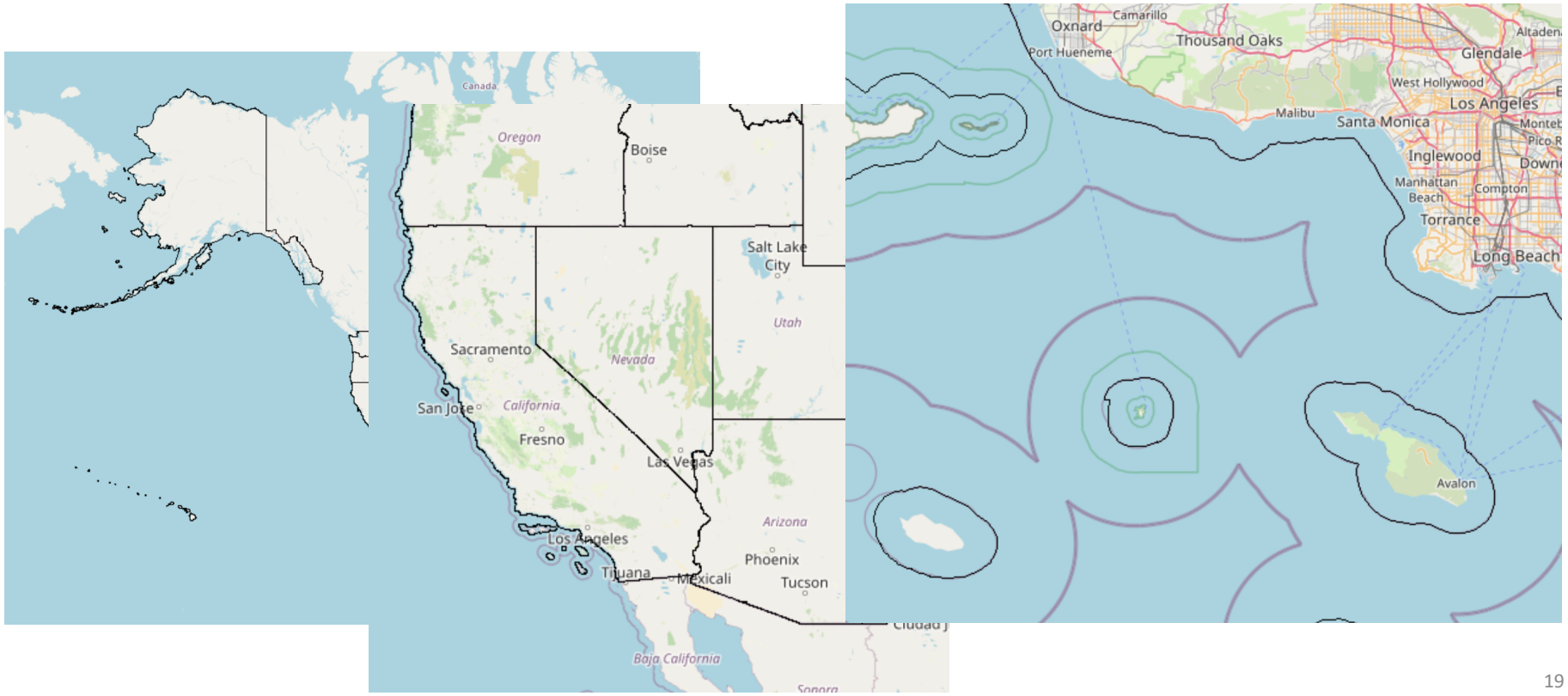
Visualization

```
// Plot states as an image
polygons.plotImage(2000, 2000, "states.png")
```



Visualization on a Map

```
// Plot states as a multilevel map
polygons.plotPyramid("states", 10,
  opts = "mercator" -> "true")
```



Writing the output

```
// Save the output as a decompressed shapefile
polygons.saveAsShapefile("output.shp")
// Save the output as a GeoJSON file
polygons.saveAsGeoJSON("output.geojson")
// Save as a WKT file
polygons.saveAsWKTFile("output.tsv", 0, '\t')
// Save points as a CSV file
polygons.saveAsCSVPoints("output.csv", 0, 1, ',')
// Save as KML file
polygons.saveAsKML("output.kml")
```

Other Big Spatial Data Systems

- Apache Sedona (Formerly GeoSpark)
  - Developed at ASU
  - In incubation [http://sedona.apache.org]
- PySAL [https://pysal.org]
  - For Python users
  - Maintained by the Center for Geospatial Sciences at UCR

Summary

- There are tons of big spatial data
- Beast can help you processing big spatial data in Spark such as:
  - Loads data in standard formats
  - Manipulates feature attributes
  - Summarizes the data
  - Filters by range
  - Joins multiple datasets
  - Visualizes the results

Further Readings

- Beast Wiki Pages
  - https://bitbucket.org/eldawy/beast/wiki/Home
- Code Examples
  - https://bitbucket.org/eldawy/beast-examples/src/master/
- Visualization Paper
  - Saheli Ghosh, Ahmed Eldawy, and Shipra Jais. AID: An Adaptive Image Data Index for Interactive Multilevel Visualization, ICDE 2019, DOI>10.1109/ICDE.2019.00150