

**Windward:**

**DATA ANALYSIS TASK**

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**The task is to identify a specific type of dock according to AIS data**

The analyze Algorithm steps:

1. Getting the data:

Read the CSV data to a Pandas Dataframe

Grouping by MMSI, instantiate ship Models

2. cleaning

Each ship record that is inconsistent (had encountered changes) in the size, Class, and distances, are discarded

Ships with a mismatch in the size and distances are discarded

3. analyzing ships:

Each ship, when **speed is 0** (stopped) for **at least 4 (configurable) hours**, was counted as docked for that period. The docking locations were saved

4. analyzing docking locations:

Each saved docking location, that its distance is larger than the configurable resolution, instantiates a dock Model

**The dock model has:**

Latitude, longitude and heading

And from the docked ships we can learn: the min/max size/width of the ships in can consist and the classes of ships docked

In addition I used Google Static Map API to get a satellite image and the Elevation API (which was according to the documentation to give the depth, but only gives sea level according to my observations)

## About the data

### General info about the given data

[56057 rows x 12 columns]

#### Columns:

Time, MMSI, Latitude, Longitude, Speed, Heading, Class, Size, DistanceToBow, DistanceToStern, DistanceToPort

**Date format:** "yyyy-MM-dd hh:mm:ss"

```
len (set(df['MMSI']))
```

There are 327 different MMSI

```
max(df['Latitude'])
```

52.010829999999999

```
min(df['Latitude'])
```

51.844949999999997

```
max(df['Longitude'])
```

4.5812230000000005

```
min(df['Longitude'])
```

3.9503330000000001

#### Stats:

30 ships has metadata consistency problem

109 ships are not well measured

215 ships are bigger the 200

## Extra: Histogram tool

The docks can be briefly identified using a histogram plot of all data's longitude and latitude, assuming that a position should be occurring a lot more where it represents a dock ( a ship transmitted a lot from the same position: the location can be obtained by comparing the occurrences of the specific coordinate. Figure [1] and Figure [2]

A docking state can be flagged also where the heading of ship equals to one of the occurring heading in the heading histogram Figure [3]

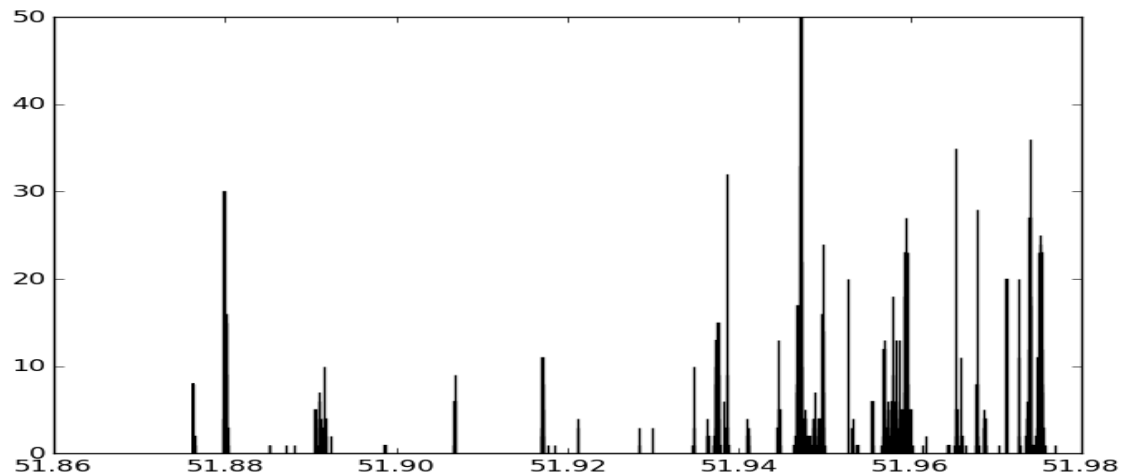


Figure 1 histogram of ships longitudes

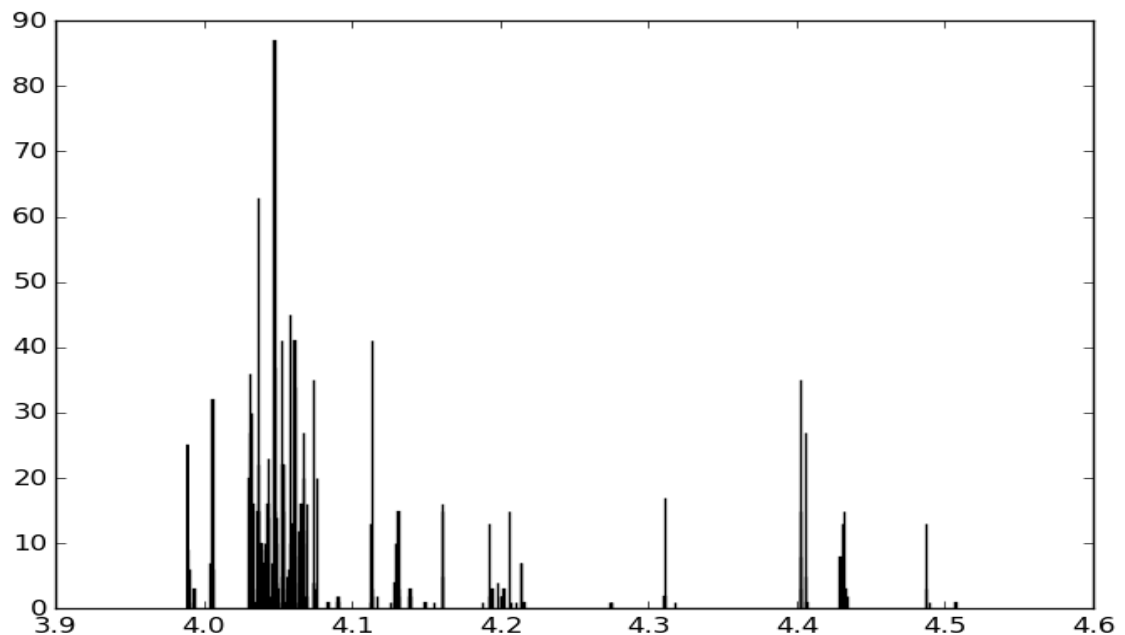
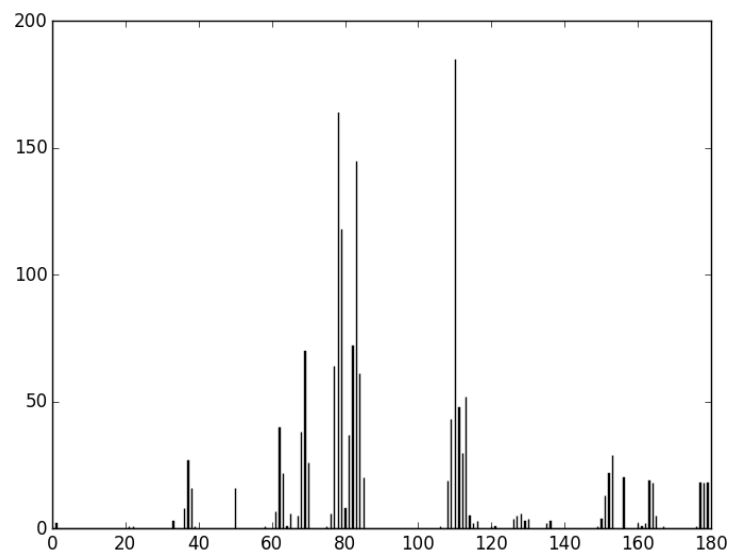


Figure 2 histogram of ships latitudes



*Figure 3 Heading angle of all ships*

## System design and assumptions

### Data Integrity tests:

1. Consistency of data that is entered manually: 'MMSI','Class', 'Size', 'DistanceToBow', 'DistanceToStern', 'DistanceToPort', 'DistanceToStarboard'
2.  $size == distance\ to\ bow + distance\ to\ stern$   
 $width < size$

### Configuration:

All system configuration and parameters controlled via the configuration module

### Assumptions

#### Docking locations assumptions:

1. Docking meaning speed =0
2. minimal docking time: 4 hours (configurable)
3. heading = constant on docking ( not used)
4. Elevation (depth) google api – only sea level acquired, can disqualify terrain errors
5. What google api: locations (optional )
6. satellite image with orientation [2]

#### Relevant ship assumptions:

1. minimal size of ship = 250m (configurable)
2. not marked as classes: “High speed craft”, “Military or law”, “Fishing”, “Passenger”, “Pleasure”
3. are consistent in entered parameters (mmsi, class, size and distances ) meaning the AIS was set professionally and is reliable

## A talk about distances and Angles

x amount of size (in meters) is equivalent to :

$r_a = 6378134 \text{ m}$  ,  $r_b = 6356752.31 \text{ m}$  (Wikipedia[1])

a. earth is sphere:

b. earth is ellipsoid- [out of scope]

we will talk only on the sphere case

$r = (r_a + r_b) / 2 = 6367443.155 \text{ m}$

$\Delta x = (\Delta \text{long} / 360) * \pi * r$

$\Delta y = (\Delta \text{lat} / 360) * \pi * r$

$\alpha * \text{Angle} = \text{Distance}$

(Or in short, multiply by  $\alpha = 55566.424$  do get the distance between two angles)

Now let's calculate the Google maps zoom size:

We want to see about 5 cm : 200 m ratio (sized ship), meaning :  $200 / 0.05 = \text{times: } 4000$

Where zoom = 1, the closest zoom we have is  $2^{\text{ZOOM}} = 12$ :  $2^{12} = 4096$ .

Meaning a fraction of times 4096 of each axis comparing to full map: zoom=1  $\rightarrow [-180:180], [-90:90]$

Given L is the latitude axis length,  $L / 4096 = \Delta y = \alpha * \Delta \text{lat}$

$\Delta \text{limit\_latitude}, \Delta \text{limit\_logitude} = L_x, L_y / (\alpha * 4096)$

$\alpha = 55566.424$ ,  $L_y = 40007860 \text{ m}$ ,  $L_x = 40075016 \text{ m}$

let's determine minimal angular resolution: let say 100 m [0.1?], (minimal angle of where we wish to classify an object in space. Well take it slightly less than the ships size)

Meaning :

$\Delta \text{lat\_resolution} = 100 / (555.66424 * 2^{\text{ZOOM}}) = 10 / 2276000.72704 = 4.39 * 10^{-5} [\text{degrees}]$

Meaning we need only 5 numbers after a decimal point accuracy

**REMARK-** it turned out I could not predict the Google Api Zoom scale, but this exercise did a great deal to understand and asses the resolution



## Results:

On the setting of resolution = 0.001647 degrees: the system detected 58 docks.

Here are the first 4 out of total 58 desired docks found (can be maybe calibrated to more, with the cost of duplicates by setting the resolution)

more images can be found at:

<https://picasaweb.google.com/116781616540240633183/PredictedDocks>

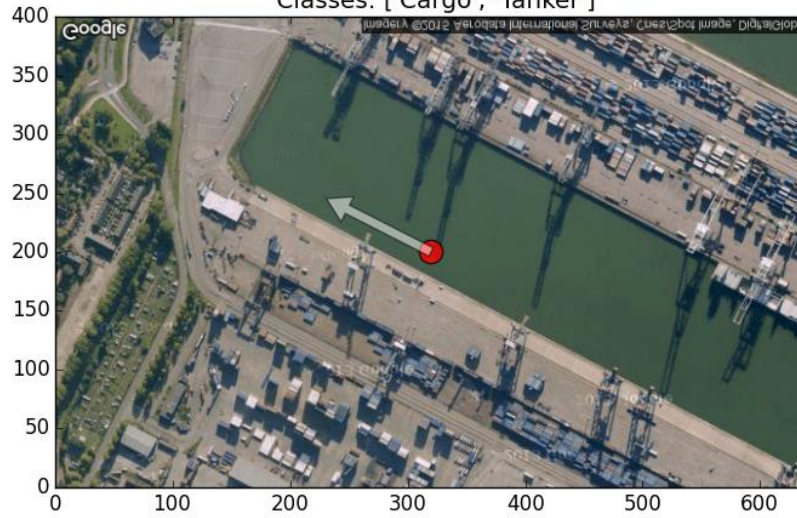
The code:

[https://github.com/forye/docks\\_images](https://github.com/forye/docks_images)

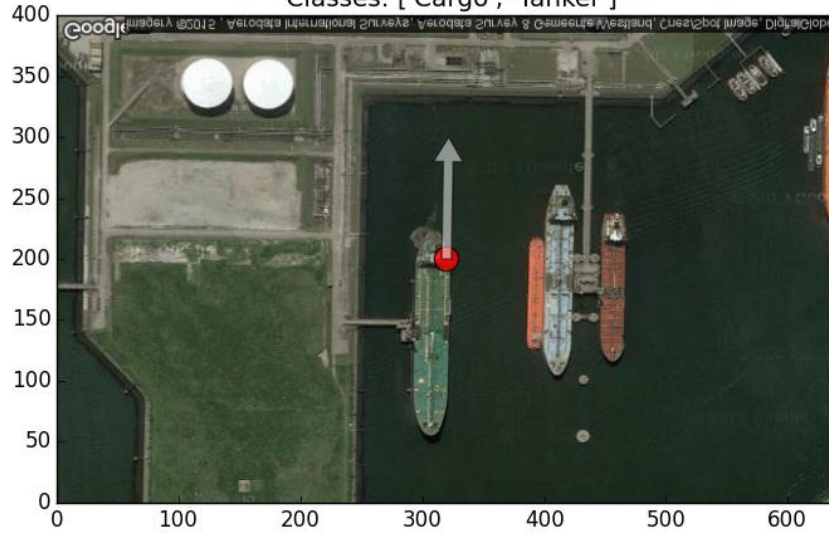
After installing all the correct module, run `get_docks_candidates.py`, to replicate the results,

Play with the configuration at `config/configuration.py`

Longitude:4.43041 Latitude:51.89093 Heading:63 Elevation:0.644188463686  
Docked Ships Count: 49 size: 254 to 300m width: 30.0 to 48.0  
Classes: ['Cargo', 'Tanker']



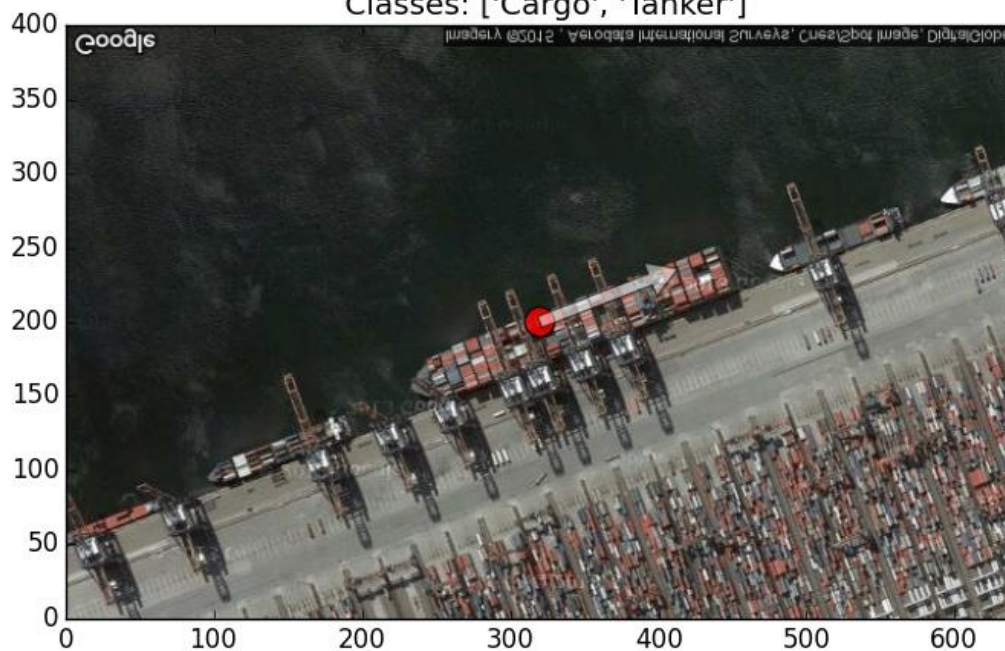
Longitude:4.138867 Latitude:51.95333 Heading:359 Elevation:0  
Docked Ships Count: 85 size: 254 to 396m width: 30.0 to 54.0  
Classes: ['Cargo', 'Tanker']



Longitude:4.160717 Latitude:51.94468 Heading:344 Elevation:0  
Docked Ships Count: 43 size: 254 to 396m width: 30.0 to 54.0  
Classes: ['Cargo', 'Tanker']



Longitude:4.036292 Latitude:51.97386 Heading:291 Elevation:0  
Docked Ships Count: 56 size: 254 to 400m width: 30.0 to 60.0  
Classes: ['Cargo', 'Tanker']



## references

[1] Wikipedia

<https://en.wikipedia.org/wiki/Earth>

[2] Google Static Maps API

<https://developers.google.com/maps/documentation/static-maps/>

[3] Google Elevation API

<https://developers.google.com/maps/documentation/elevation/intro>

[4] GitHub public repository: the code, resources and results

[https://github.com/forye/docks\\_images.git](https://github.com/forye/docks_images.git)