IBM Developer
SKILLS NETWORK

Winning Space Race with Data Science

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Outline

- Executive Summary
- Introduction
- Methodology
- Results
- Conclusion
- Appendix

Executive Summary

- Summary of methodologies
  - API & Web scrapping for data collection
  - EDA with SQL and Python
  - Data Visualization
  - Interactive Visual Analytics with Folium and Plotly
  - Predictive Analysis - Classification
- Summary of all results
  - EDA
  - Interactive maps and charts
  - Classifications results

Introduction

- Project background and context
  - SpaceX products and services have much lower price than its competitors. Its adventage SpaceX owes to reusable first stage of rocket. We are trying to determine the criteria of a succesfull first stage launch.
- Problems you want to find answers
  - How can we describe a succesfull landing?
  - How to define optimum conditions for succesfull launch and landing?

Section 1

Methodology

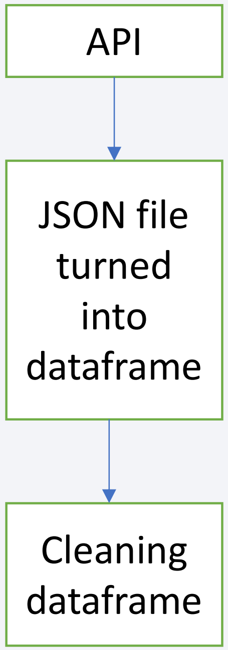
Methodology

Executive Summary

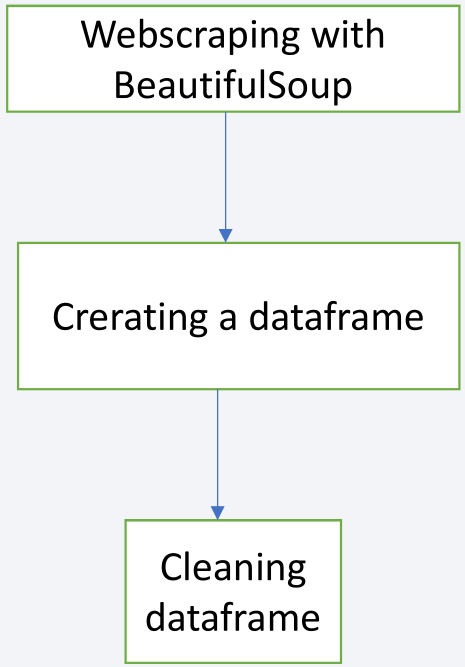
- Data collection methodology:
  - REST API by SpaceX
  - Web Scraping
- Perform data wrangling
  - Data frames cleaning and modification with Pandas
- Perform exploratory data analysis (EDA) using visualization and SQL
- Perform interactive visual analytics using Folium and Plotly Dash
- Perform predictive analysis using classification models
  - How to build, tune, evaluate classification models

Data Collection

Data sets were first collected with use of API. These were in format of JSON files.



Secondly web scraping from wikipedia was used.



Data Collection - SpaceX API

Task 1: Request and parse the SpaceX launch data using the GET request

To make the requested JSON results more consistent, we will use the following static response object for this project:

```
In [9]: static_json_url='https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBM-DS0321EN-SkillsNetwork/datasets/API_call_spacex_api.json'
```

```
# Use json_normalize meethod to convert the json result into a dataframe
response = requests.get(static_json_url)
# response.json() - w ten sposób mogę zobaczyć co jest w pliku w formacie json
data = pd.json_normalize(response.json())
```

[code link]

Data Collection - Scraping

```python
static_url = "https://en.wikipedia.org/w/index.php?title=List_of_Falcon_9_and_Falcon_Heavy_launches&oldid=1027686922"
```

```python
# use requests.get() method with the provided static_url
# assign the response to a object
response = requests.get(static_url).text
```

Create a `BeautifulSoup` object from the HTML `response`

```python
# Use BeautifulSoup() to create a BeautifulSoup object from a response text content
soup = BeautifulSoup(response, 'html.parser')
```

```python
# Use the find_all function in the BeautifulSoup object, with element type `table`
# Assign the result to a list called `html_tables`
html_tables = soup.find_all('table')
```

[code link]

Data Wrangling

Some of the necassary sets of the colelcted data were transformed into numerical values and additional landing class series was created.
Finaly data frame was exported to CSV file.

```
landing_class = []
for i in df['Outcome']:
    if i in bad_outcomes:
        landing_class.append(0)
    else:
        landing_class.append(1)
```

```
df.to_csv("dataset_part_2.csv", index=False)
```

[code link]

EDA with Data Visualization

Graphs used in the project

- Success rate vs. Year (line graph)
- Success rate cs. Orbit (bar graph)
- Payload vs. Orbit Type (scatter graph)

code link

EDA with SQL

Following EDA with SQL tasks were performed:

- Display the names of the unique launch sites in the space mission
- Display 5 records where launch sites begin with the string 'CCA’
- Display the total payload mass carried by boosters launched by NASA (CRS)
- Display average payload mass carried by booster version F9 v1.1
- List the date when the first successful landing outcome in ground pad was acheived.
- List the names of the boosters which have success in drone ship and have payload mass greater than 4000 but less than 6000
- List the total number of successful and failure mission outcomes
- List the   names of the booster_versions which have carried the maximum payload mass. Use a subquery
- List the failed landing_outcomes in drone ship, their booster versions, and launch site names for in year 2015
- Rank the count of landing outcomes (such as Failure (drone ship) or Success (ground pad)) between the date 2010-06-04 and 2017-03-20, in descending order

code link

Build an Interactive Map with Folium

A Folium map was added to the project. There are several key points marked with an orange circle added to the map:

- NASA Johnson Space Center
- Launch sites
- Markers presenting successful (green) and unsuccessful (red) launches on a launch site.
- Markers presenting distance from launch site to a key location

Object were presented for better understanding data characteristics.

code link

Build a Dashboard with Plotly Dash

For better understanding and visualizing data investigated in the project dashboard with dropdown was implemented.

Its conencted to pie chart representing success/fail ratio of a chosen launch site.

It is also possible to navigate through payload mass with use of a rangeslider

Scatter plot was used to prsent relationship between success and payload mass.

code link

Predictive Analysis (Classification)

- The best model was found and implemented out of four (KNN, LogReg, SVM, Decission Tree).
- GridSearch CV with determined parameters was used for each model

KNN, LogReg, SVM, Decission Tree → GridSearchCV for each → Best score

code link

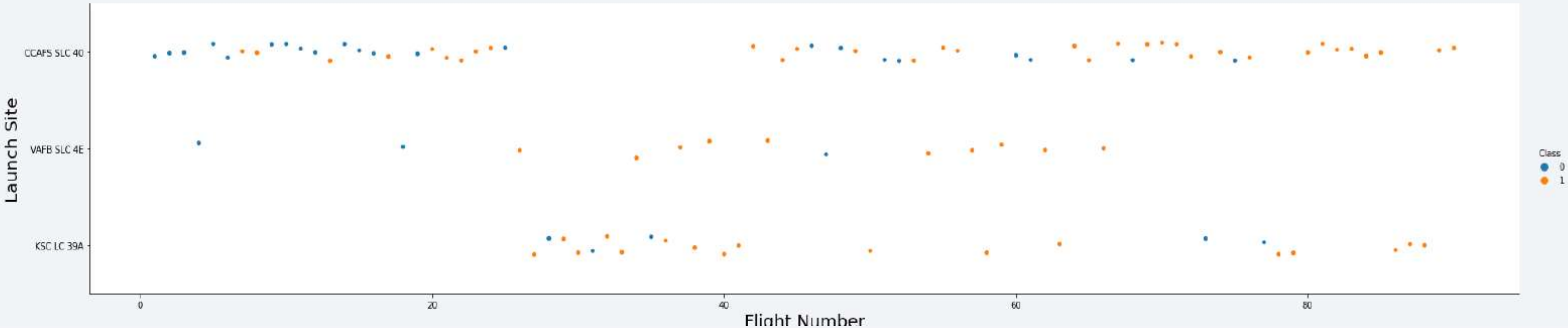
Results

- Exploratory data analysis results
- Interactive analytics demo in screenshots
- Predictive analysis results

Section 2

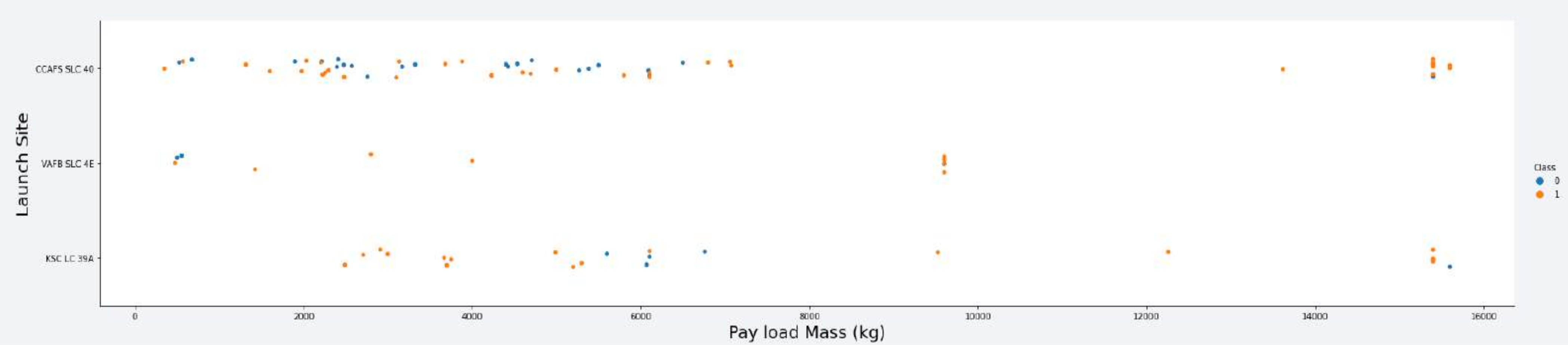
Insights drawn from EDA

Flight Number vs. Launch Site



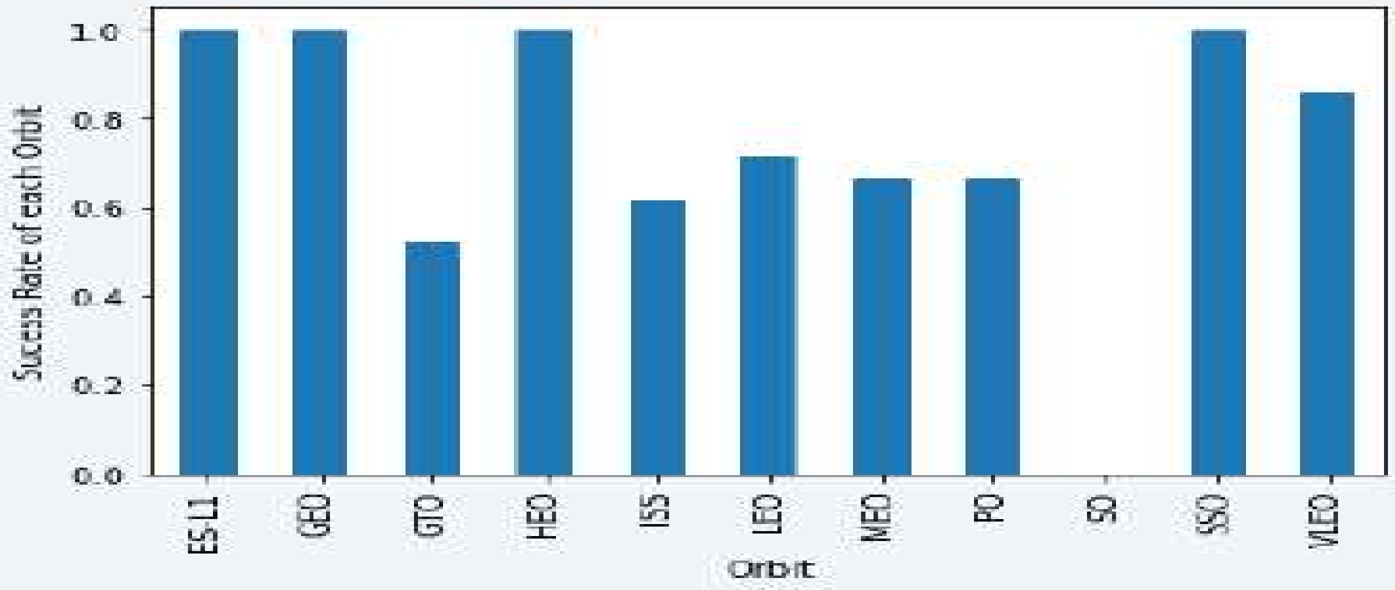
The more trials the better result

Payload vs. Launch Site



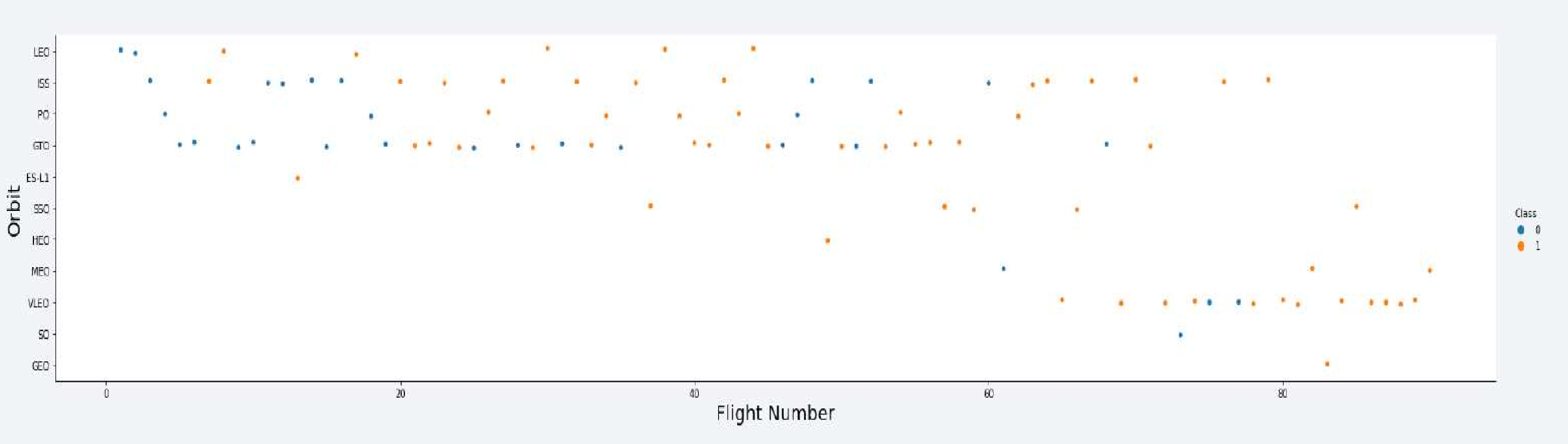
Two launch sites are able to service a heavy payload.

Success Rate vs. Orbit Type



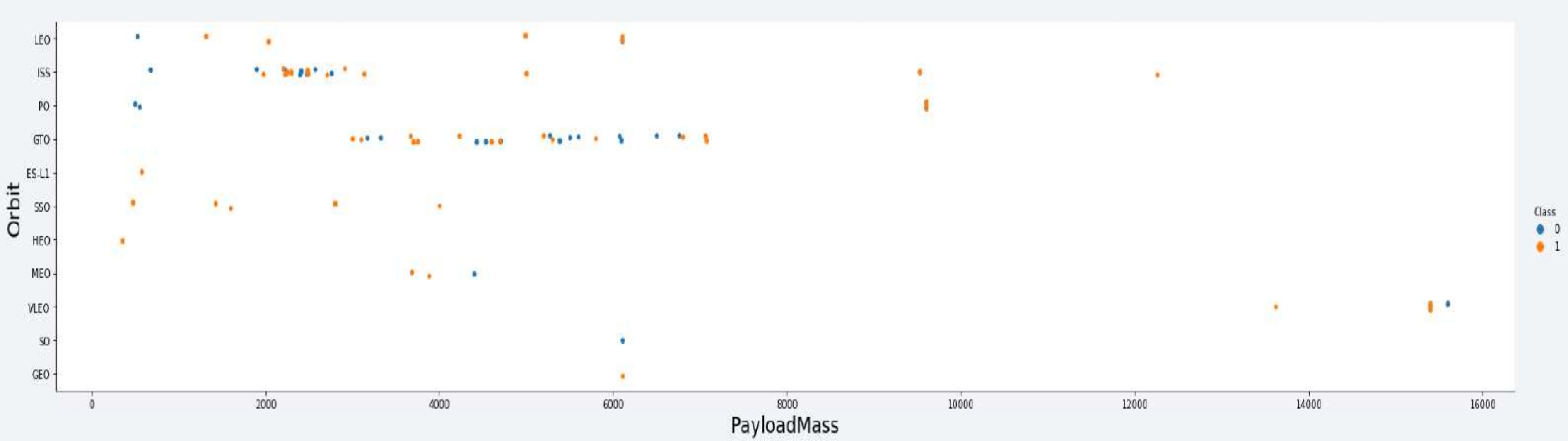
Four out of all orbit types considered in the project have success rate of 1 (100% success)

Flight Number vs. Orbit Type



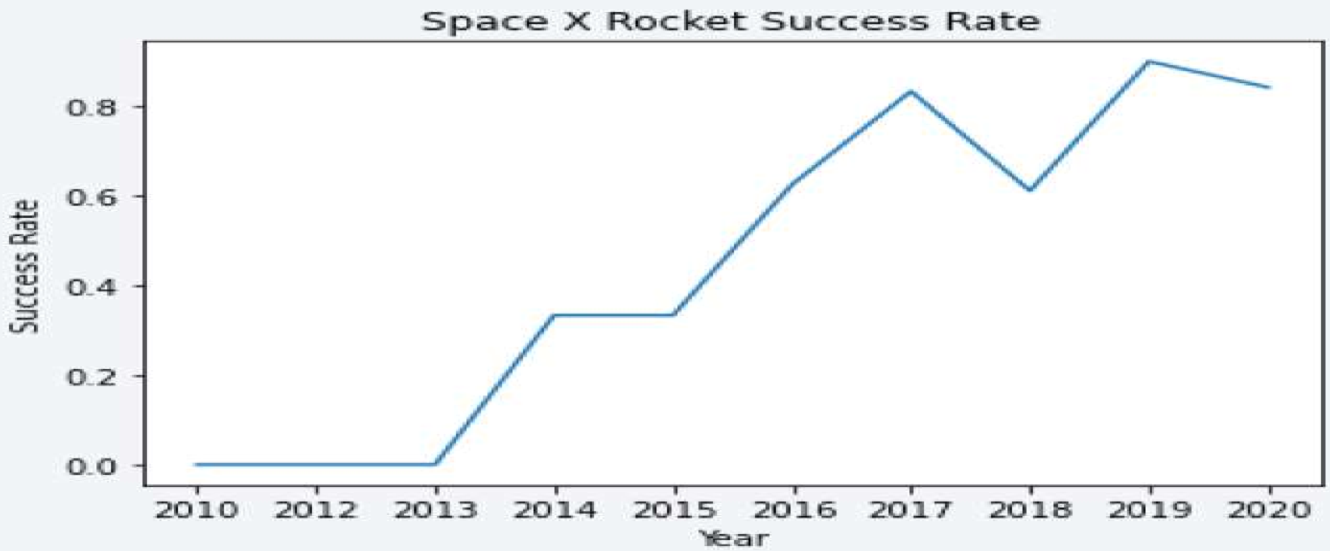
First flights were not satisfactorily successful. With increase of flight numbers we observe less blue points (unsuccessfull launnches). Also increase of flight numbers was accompanied by diversification of targeted orbits.

Payload vs. Orbit Type



It is visible that large payload launches were more succesful and the largest were sent to only one orbit. Small payloads were launched rarely. Worth mentioning is a fact that some orbits have only successful launches

Launch Success Yearly Trend



A clear trend is visible. SpaceX seems to gain experience year by year which result in increasing success rate.

All Launch Site Names

```
SELECT DISTINCT "LAUNCH_SITE" FROM SPACEXTBL
```

Launch_Site
CCAFS LC-40
VAFB SLC-4E
KSC LC-39A
CCAFS SLC-40

Launch Site Names Begin with 'CCA'

```
SELECT * FROM SPACEXTBL WHERE "LAUNCH_SITE" LIKE '%CCA%' LIMIT 5
```

Date	Time (UTC)	Booster_Version	Launch_Site	Payload	PAYLOAD_MASS__KG_	Orbit	Customer
04-06-2010	18:45:00	F9 v1.0 B0003	CCAFS LC-40	Dragon Spacecraft Qualification Unit	0	LEO	SpaceX
08-12-2010	15:43:00	F9 v1.0 B0004	CCAFS LC-40	Dragon demo flight C1, two CubeSats, barrel of Brouere cheese	0	LEO (ISS)	NASA (COTS) NRO
22-05-2012	07:44:00	F9 v1.0 B0005	CCAFS LC-40	Dragon demo flight C2	525	LEO (ISS)	NASA (COTS)
08-10-2012	00:35:00	F9 v1.0 B0006	CCAFS LC-40	SpaceX CRS-1	500	LEO (ISS)	NASA (CRS)
01-03-2013	15:10:00	F9 v1.0 B0007	CCAFS LC-40	SpaceX CRS-2	677	LEO (ISS)	NASA (CRS)

Result was reachad by filtering by WHERE + LIKE and it was limited to 5 by LIMIT.

Total Payload Mass

```
SELECT SUM("PAYLOAD_MASS__KG_") FROM SPACEXTBL WHERE "CUSTOMER" = 'NASA (CRS)'
```

SUM("PAYLOAD_MASS__KG_")
45596

The above formula calculates total payload mass ordered by NASA

Average Payload Mass by F9 v1.1

```
SELECT AVG("PAYLOAD_MASS__KG_") FROM SPACEXTBL WHERE "BOOSTER_VERSION" LIKE '%F9 v1.1%'
```

AVG("PAYLOAD_MASS__KG_")
2534.6666666666665

- The above SQL formulas return average payload mass carried by a F9 1.1 rocke version

First Successful Ground Landing Date

```
SELECT MIN("DATE") FROM SPACEXTBL WHERE "Landing _Outcome" LIKE '%Success%'
```

MIN("DATE")
01-05-2017

The above formula retuns minimum value from a DATE under contition that landing was successful . That is how we receive a date of the first successful landing.

Successful Drone Ship Landing with Payload between 4000 and 6000

```
%sql SELECT "BOOSTER_VERSION" FROM SPACEXTBL WHERE "LANDING _OUTCOME" = 'Success (drone ship)' \
AND "PAYLOAD_MASS__KG_" > 4000 AND "PAYLOAD_MASS__KG_" < 6000;
```

Booster_Version
F9 FT B1022
F9 FT B1026
F9 FT B1021.2
F9 FT B1031.2

The above SQL formula returns number of drones with had payloads between 4000 and 6000 that landed successfuly.

Total Number of Successful and Failure Mission Outcomes

```
%sql SELECT (SELECT COUNT("MISSION_OUTCOME") FROM SPACEXTBL WHERE "MISSION_OUTCOME" LIKE '%Success%') AS SUCCESS, \
(SELECT COUNT("MISSION_OUTCOME") FROM SPACEXTBL WHERE "MISSION_OUTCOME" LIKE '%Failure%') AS FAILURE
```

SUCCESS	FAILURE
100	1

Outcomes are filtered, than added and displayed in relevant columns - SUCCESS and FAILURE.

Boosters Carried Maximum Payload

```
%sql SELECT DISTINCT "BOOSTER_VERSION" FROM SPACEXTBL \
WHERE "PAYLOAD_MASS__KG_" = (SELECT max("PAYLOAD_MASS__KG_") FROM SPACEXTBL)
```

Booster_Version
F9 B5 B1048.4
F9 B5 B1049.4
F9 B5 B1051.3
F9 B5 B1056.4
F9 B5 B1048.5
F9 B5 B1051.4
F9 B5 B1049.5
F9 B5 B1060.2
F9 B5 B1058.3
F9 B5 B1051.6
F9 B5 B1060.3
F9 B5 B1049.7

The above formula filters payloads and returns only heaviest. Finaly names of heaviest payloads are returned.

2015 Launch Records

```
%sql SELECT substr("DATE", 4, 2) AS MONTH, "BOOSTER_VERSION", "LAUNCH_SITE" FROM SPACEXTBL\
WHERE "LANDING _OUTCOME" = 'Failure (drone ship)' and substr("DATE",7,4) = '2015'
```

MONTH	Booster_Version	Launch_Site
01	F9 v1.1 B1012	CCAFS LC-40
04	F9 v1.1 B1015	CCAFS LC-40

The above code returns failed landings on a drone ship that took place in 2015.

Rank Landing Outcomes Between 2010-06-04 and 2017-03-20

```
%sql SELECT "LANDING _OUTCOME", COUNT("LANDING _OUTCOME") FROM SPACEXTBL\
WHERE "DATE" >= '04-06-2010' and "DATE" <= '20-03-2017' and "LANDING _OUTCOME" LIKE '%Success%'\
GROUP BY "LANDING _OUTCOME" \
ORDER BY COUNT("LANDING _OUTCOME") DESC ;
```

Landing _Outcome	COUNT("LANDING _OUTCOME")
Success	20
Success (drone ship)	8
Success (ground pad)	6

The above query groups entries by landing outcome. Data is arranged in descending order. Count of landing orders of successful launches and landing is returned.

Section 3

Launch Sites Proximities Analysis

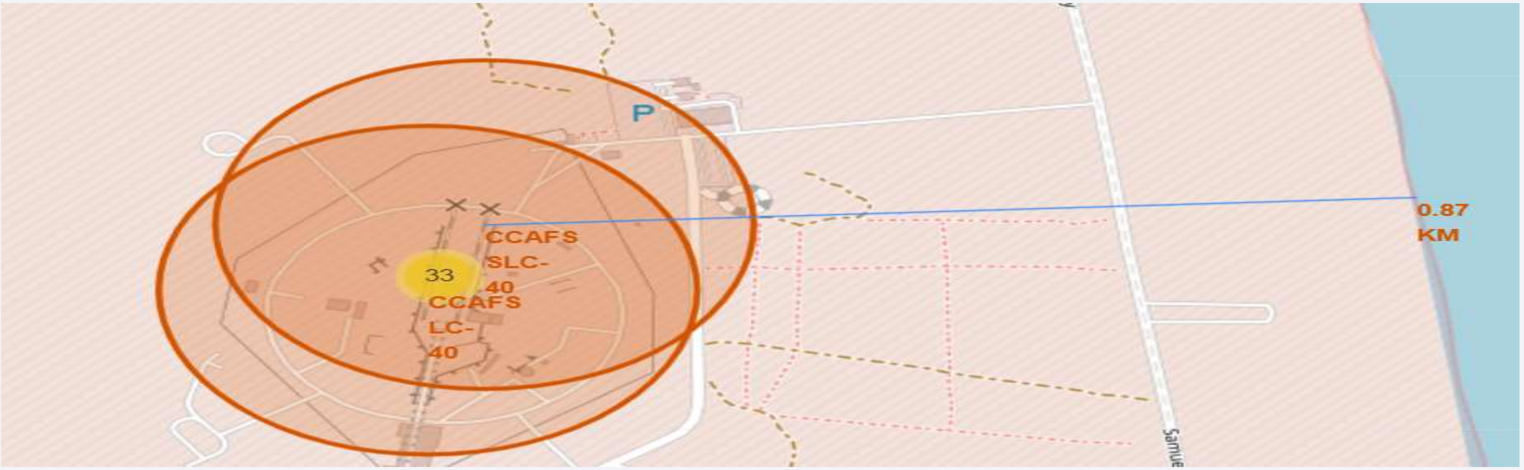
Launch Sites Location

SpaceX are located at ocean shores.

Succes/Fail per launch site

In each launch site sucessful mission was pointed by a green marker. Mission that was a failure received a red marker.

Launch Sites proximities



Each launch site needs to be close to important proximities, in particular to:

railway

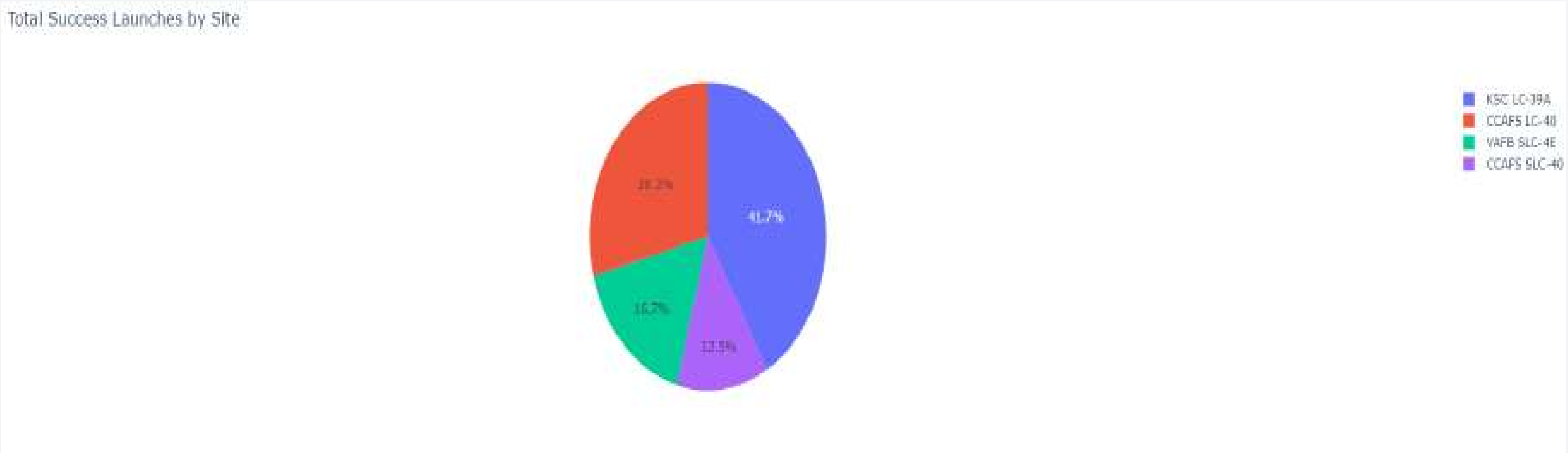
highway

coastline

Section 4

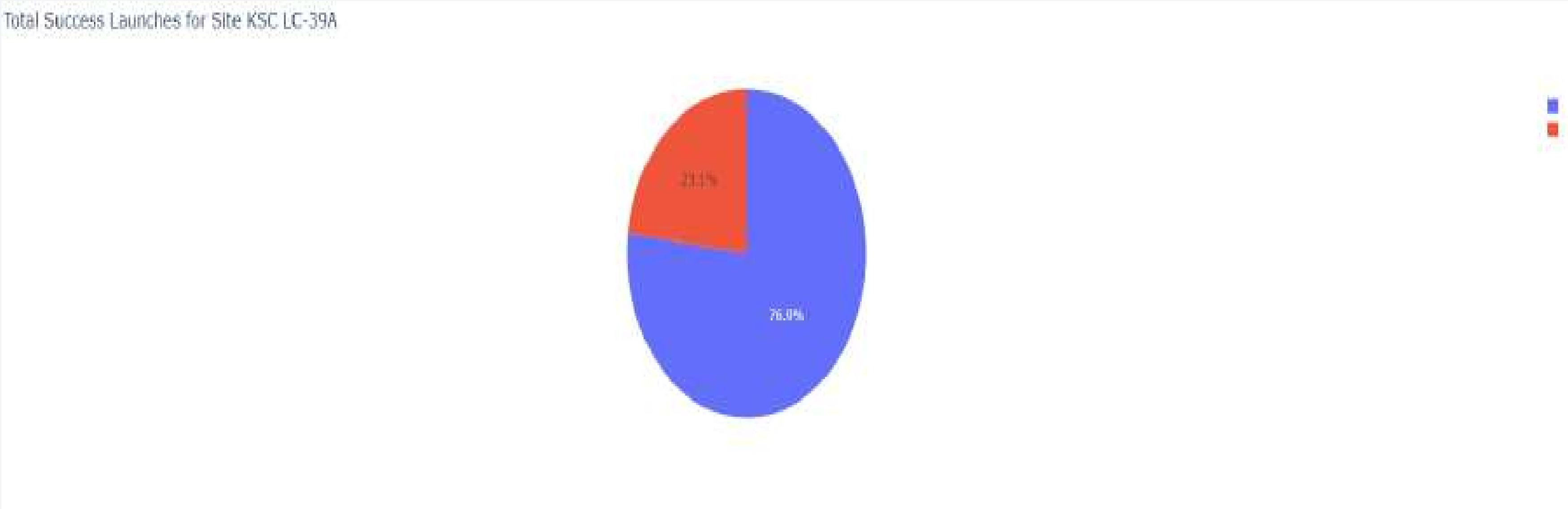
Build a Dashboard with Plotly Dash

Site effectiveness



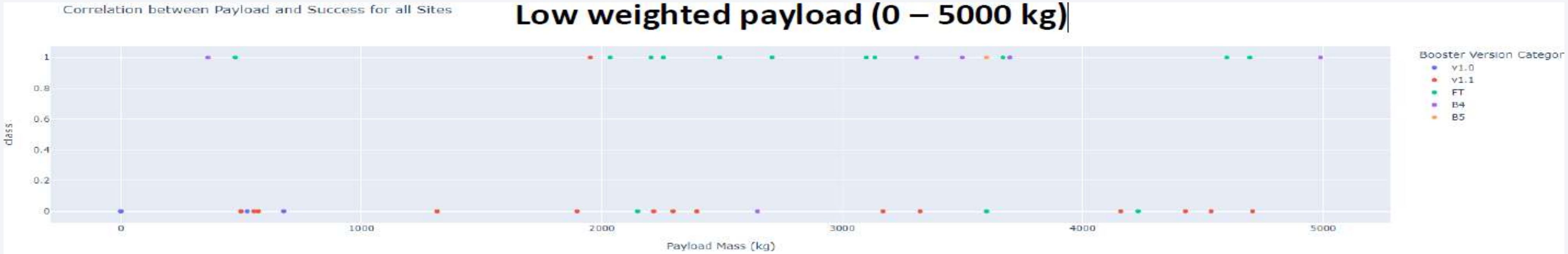
It is clear that KSC LC-39A launch site is most effective.

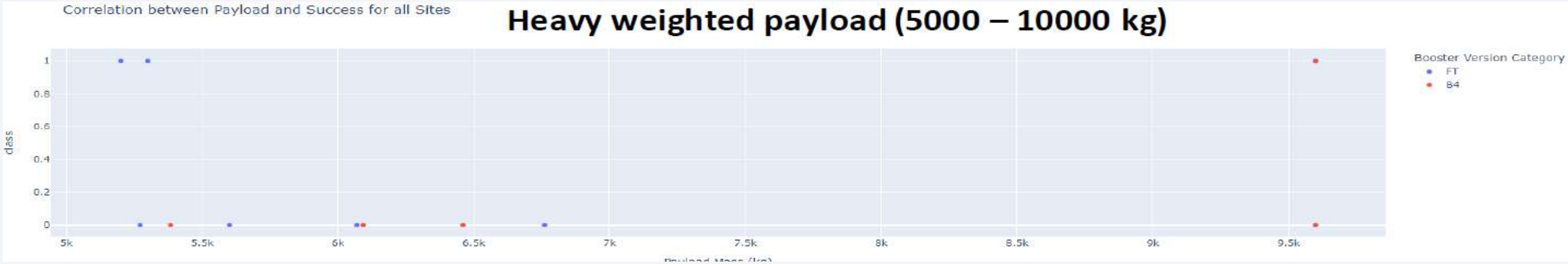
KSC LC-39A launch site effectiveness



Almost 77% missions were succesfull.

Low vs high payload effectiveness



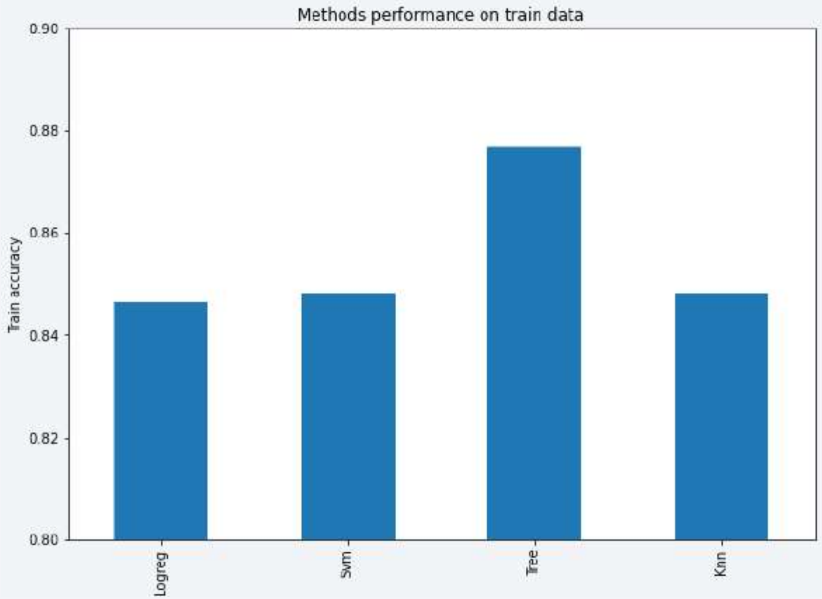


Only two launch sites were used for heaviest loads. Launching lighter payloads has more succeses.

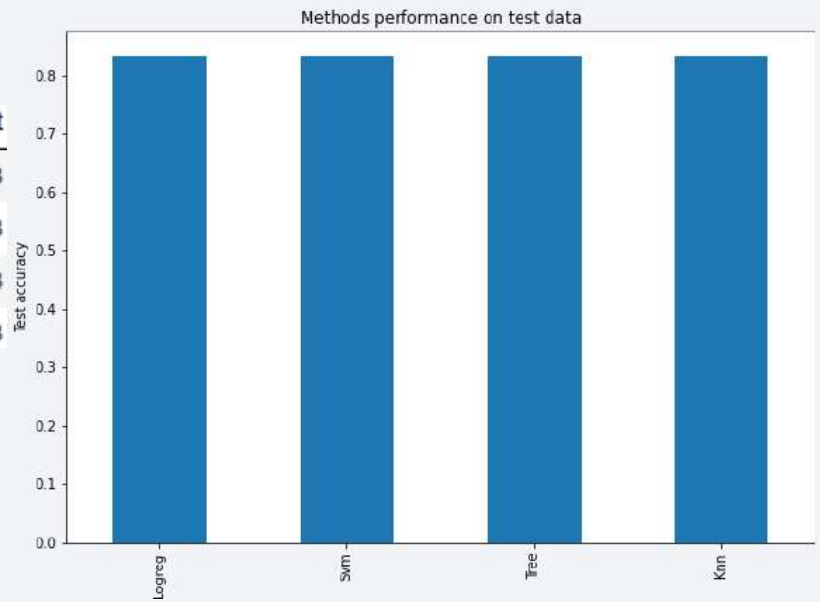
Section 5

Predictive Analysis (Classification)

Classification Accuracy

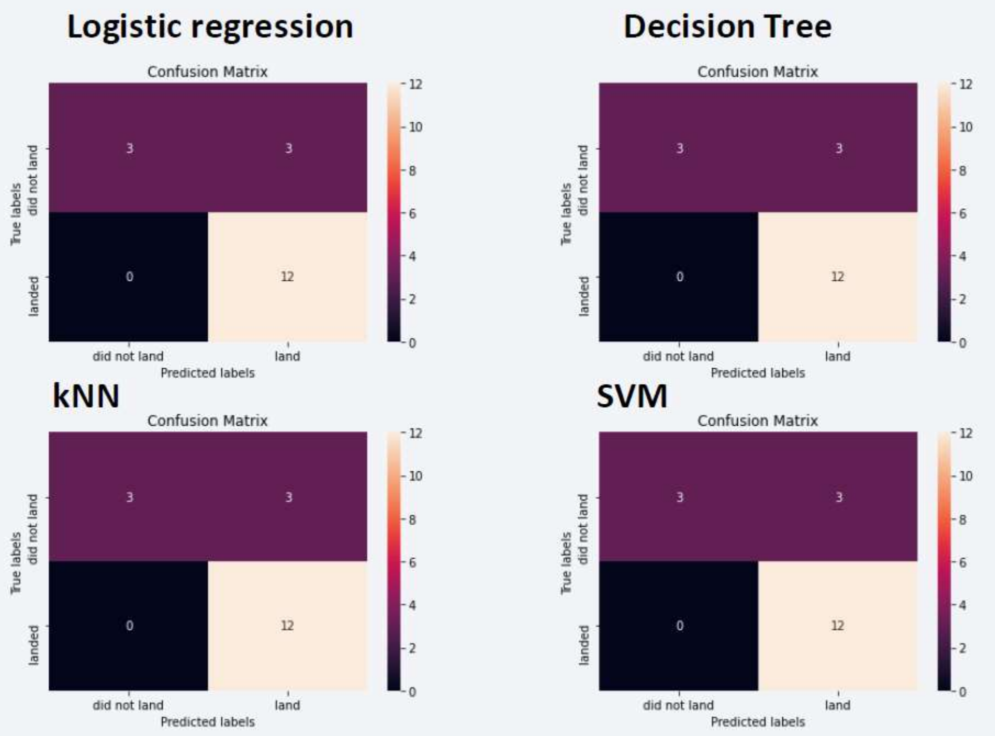


Accuracy Train	Accuracy Test
0.876786	0.833333
0.848214	0.833333
0.848214	0.833333
0.846429	0.833333



The best choice of a model for our project would be Decission Tree. It performed best on train data. Accuracy test were the same for all implemented models.

Confusion Matrix



False positives are most problematic for each model.

Conclusions

- It is clearly visible that with time success/fail ratio of SpaceX launches increased
- With data we were provided it is impossible to justify superiority of KSC LC-39A launch site.
- It is best to launch a rocket directing GEO, SSO, ES-L1 or HEO orbit.
- Some orbits seem to be more suitable for heavier payloads.
- Due to best train accuracy we recomend to use a Deciision Tree clasifier.

Appendix

Wikipedia SpaceX Falcon 9 link:

https://en.wikipedia.org/wiki/List_of_Falcon_9_and_Falcon_Heavy_launches


Thank you!