dbagan_PEC3_modificaciones

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0.0.1 Librerías

[528]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from keras.layers.core import Dense, Activation, Dropout, Flatten
from keras.layers import LSTM, BatchNormalization
from keras.models import Sequential
from tensorflow.keras.optimizers import Adam
from sklearn.preprocessing import StandardScaler, MinMaxScaler
from sklearn.utils import shuffle
import haversine as hs
from haversine import Unit
import joblib
import math
import geopy
import geopy.distance
import folium
from shapely import geometry, ops
import time
```

0.0.2 EDA

[529]:
```
df = pd.read_csv("positions_1000.csv")
```

[530]:
```
df = shuffle(df)
```

[531]:
```
df.head()
```

[531]:
```
          time  vehicle_id  victim_id   latitude  longitude      speed  \
2287287  11561        9439         -1  41.391807   2.165370   0.062439
2793139  14103       11848         -1  41.390956   2.165465   0.000000
1696045   8589        7100         -1  41.391666   2.165597   0.000000
3478531  17547       14929         -1  41.388466   2.163740  10.770545
2083999  10538        9005         -1  41.390053   2.166574   3.943876
```

```
         heading  collision
2287287  317.547946          0
2793139   45.738504          0
1696045  317.458691          0
3478531  136.050655          0
2083999  225.260525          0
```

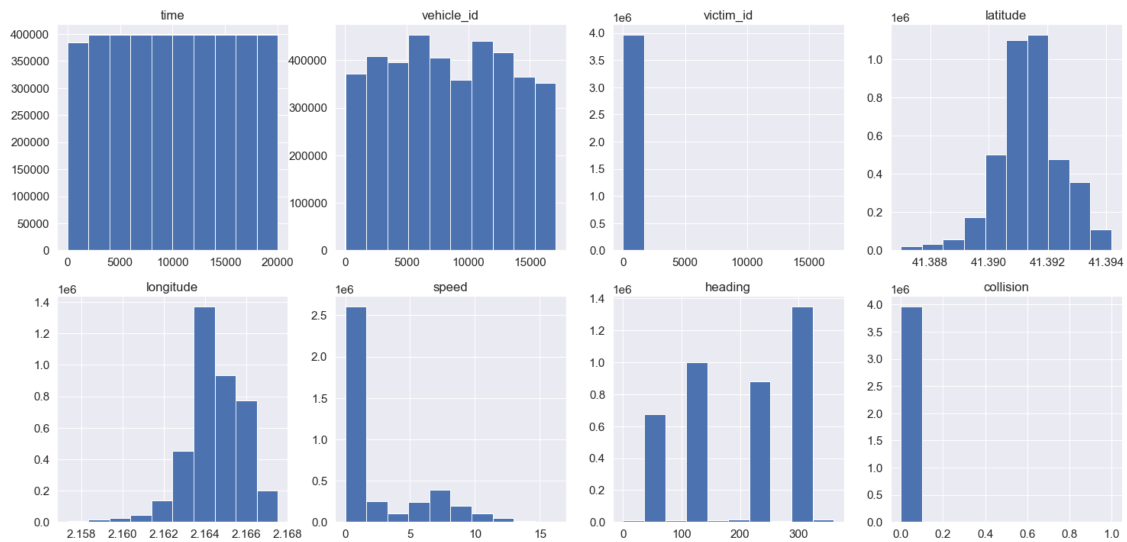
[532]:
```python
df.shape
```

[532]:
```
(3966377, 8)
```

[533]:
```python
df.describe()
```

[533]:
```
               time    vehicle_id     victim_id      latitude     longitude  \
count  3.966377e+06  3.966377e+06  3.966377e+06  3.966377e+06  3.966377e+06
mean   1.003159e+04  8.435308e+03  1.286898e+00  4.139137e+01  2.164493e+00
std    5.755679e+03  4.812723e+03  1.607677e+02  1.097701e-03  1.362169e-03
min    0.000000e+00  3.000000e+00 -1.000000e+00  4.138700e+01  2.157329e+00
25%    5.050000e+03  4.358000e+03 -1.000000e+00  4.139077e+01  2.163715e+00
50%    1.003200e+04  8.346000e+03 -1.000000e+00  4.139136e+01  2.164423e+00
75%    1.501600e+04  1.250500e+04 -1.000000e+00  4.139199e+01  2.165491e+00
max    1.999900e+04  1.710200e+04  1.700300e+04  4.139418e+01  2.167546e+00

              speed       heading     collision
count  3.966377e+06  3.966377e+06  3.966377e+06
mean   2.307072e+00  2.030676e+02  2.657337e-04
std    3.478560e+00  1.001039e+02  1.629918e-02
min    0.000000e+00  4.126121e-04  0.000000e+00
25%    0.000000e+00  1.357220e+02  0.000000e+00
50%    0.000000e+00  2.254755e+02  0.000000e+00
75%    4.954288e+00  3.174587e+02  0.000000e+00
max    1.622598e+01  3.599969e+02  1.000000e+00
```

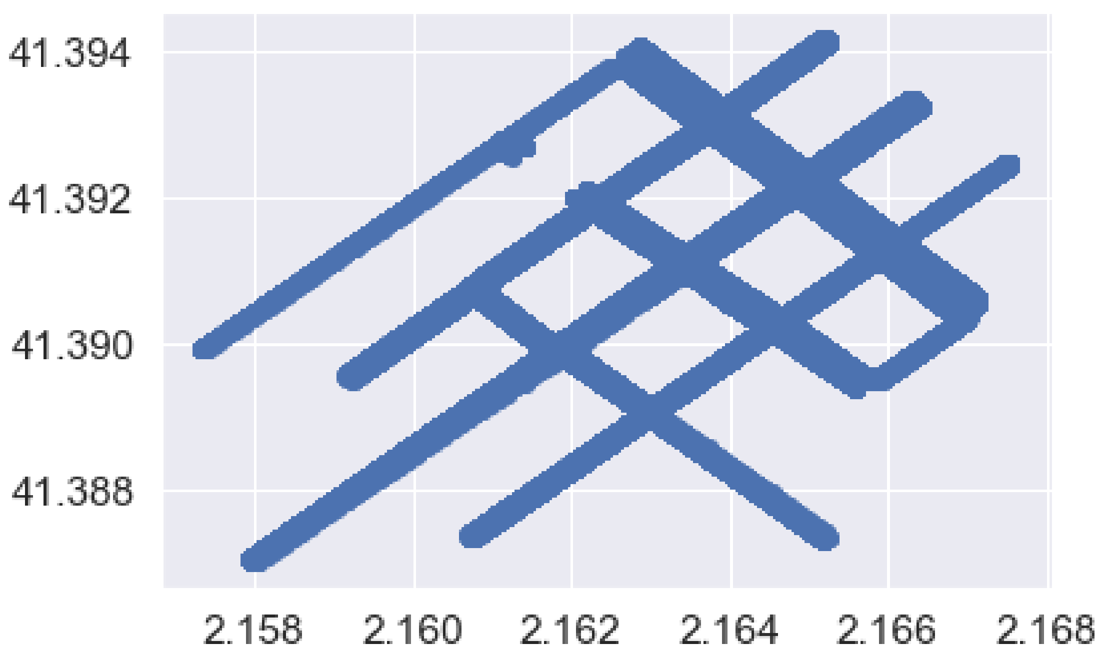
[534]:
```python
cols = df.columns
fig, ax = plt.subplots(nrows=2, ncols=len(cols)//2, figsize=(25,12))
for i in range (len(cols)):
    ax[i//4][i%4].hist(df[cols[i]])
    ax[i//4][i%4].set_title(cols[i])
```




```
[535]: total_collisions = len(df['collision'].loc[df['collision'] != 0])
       print(f"Total collisions: {total_collisions}")
       print("Total different vehicles: {0}".format(len(df["vehicle_id"].unique())))
```

```
Total collisions: 1054
Total different vehicles: 15756
```

```
[536]: plt.scatter(x=df['longitude'], y=df['latitude'])
       plt.show()
```



1 Modelos de regresión

1.0.1 Load data

[537]:
```python
def format_dataset_regresion(df, n):

    df = df.sort_values(['vehicle_id', 'time'])
    df = df.reset_index(drop=True)

    X, y = [], []
    temp_X = []
    temp_i = 0
    temp_vehicle = df.loc[0, 'vehicle_id']

    for i in range(1, df.shape[0]):

        row = df.loc[i]

        if row["vehicle_id"] != temp_vehicle:
            temp_vehicle = row["vehicle_id"]
            temp_i = 0
            temp_X = []
            temp_X.append([row["latitude"], row["longitude"]])

        elif temp_i < n:
            temp_X.append([row["latitude"], row["longitude"]])

        else:
            X.append(temp_X)
            y.append([row["latitude"], row["longitude"]])
            temp_X = []
            temp_i = 0
            temp_vehicle = -1

        temp_i += 1

    X = np.array(X, dtype='float64')
    y = np.array(y, dtype='float64')

    return X, y

#X_set, y_set = format_dataset_regresion(df, 26)
#np.save(file="./X_nparray_26.npy", arr=X_set)
#np.save(file="./y_nparray_26.npy", arr=y_set)
```

[538]:
```
X_set_full = np.load("./X_nparray_26.npy")
y_set_full = np.load("./y_nparray_26.npy")
```

[539]:
```
X_set_full, y_set_full = shuffle(X_set_full, y_set_full)
X_set = X_set_full[0:1000]
y_set = y_set_full[0:1000]
```

[540]:
```
y_set_full
```

[540]:
```
array([[41.39142019,  2.16394654],
       [41.39182239,  2.16453329],
       [41.39322376,  2.16358408],
       …,
       [41.3923991 ,  2.16453908],
       [41.39174714,  2.16267759],
       [41.38927802,  2.16333392]])
```

1.0.2 Functions

[541]:
```
def get_results(model):
    res = []
    for i in range(len(X_set)):
        X = X_set[i][:-1]
        y = X_set[i][1:]
        model.fit(X, y)
        pred = model.predict([y[-1]])
        res.append(pred[0])
    return res
```

[542]:
```
def get_avg_error(pred):
    total_distance = 0
    for i in range(len(pred)):
        input = X_set[i][-1]
        total_distance += np.sqrt(np.sum(np.square(pred[i][0]-input[0]))+np.
 ↪square(pred[i][1]-input[1]))
    avg_distance = total_distance/len(pred)
    return avg_distance
```

[543]:
```
def get_avg_distance(pred):
    total_distance = 0
    for i in range(len(pred)):
        input = X_set[i][-1]
        total_distance += hs.haversine(( pred[i][0] , pred[i][1] ),( input[0],␣
 ↪input[1] ), unit=Unit.METERS)
    avg_distance = total_distance/len(pred)
    return avg_distance
```

[544]:
```python
def get_avg_distance_10_predictions(pred, real):
    avg_distances = []
    for j in range(10):
        n_pred_distance = 0
        for i in range(len(pred)):
            p = pred[i][j]
            r = real[i][j]
            n_pred_distance += hs.haversine(( p[0] , p[1] ),( r[0] , r[1] ),␣
↪unit=Unit.METERS)
        avg_distances.append((n_pred_distance)/len(pred))
    return avg_distances
```

[545]:
```python
def call_get_next_10_predictions(dataset, model):
    preds = []
    reals = []
    for data in dataset:
        pred, real = get_next_10_predictions(data, model)
        preds.append(pred)
        reals.append(real)
    return preds, reals
```

[546]:
```python
def get_next_5_predictions(data, model):
    # Prediction 1
    X = data[:-7]
    y = data[1:-6]
    model.fit(X, y)
    pred_1 = model.predict([y[-1]])
    real_1 = data[-5]

    # Prediction 2
    X = np.concatenate((data[1:-7], pred_1))
    y = np.concatenate((data[2:-7], pred_1, [real_1]))
    model.fit(X, y)
    pred_2 = model.predict([y[-1]])
    real_2 = data[-4]

    # Prediction 3
    X = np.concatenate((data[2:-7], pred_1, pred_2))
    y = np.concatenate((data[3:-7], pred_1, pred_2, [real_2]))
    model.fit(X, y)
    pred_3 = model.predict([y[-1]])
    real_3 = data[-3]

    # Prediction 4
    X = np.concatenate((data[3:-7], pred_1, pred_2, pred_3))
    y = np.concatenate((data[4:-7], pred_1, pred_2, pred_3, [real_3]))
    model.fit(X, y)
```

```
    pred_4 = model.predict([y[-1]])
    real_4 = data[-2]

    # Prediction 5
    X = np.concatenate((data[4:-7], pred_1, pred_2, pred_3, pred_4))
    y = np.concatenate((data[5:-7], pred_1, pred_2, pred_3, pred_4, [real_4]))
    model.fit(X, y)
    pred_5 = model.predict([y[-1]])
    real_5 = data[-1]

    predictions = [l.tolist() for l in␣
↪[pred_1[0],pred_2[0],pred_3[0],pred_4[0],pred_5[0]]]
    real_values = [l.tolist() for l in [real_1,real_2,real_3,real_4,real_5]]

    return predictions, real_values
```

[547]:
```
def call_get_next_10_predictions_res(dataset, model):
    preds = []
    reals = []
    for data in dataset:
        pred, real = get_next_10_predictions_res(data, model)
        preds.append(pred)
        reals.append(real)
    return preds, reals
```

[548]:
```
def get_next_10_predictions(data, model):
    # Prediction 1
    X = data[:-12]
    y = data[1:-11]
    model.fit(X, y)
    pred_1 = model.predict([y[-1]])
    real_1 = data[-10]

    # Prediction 2
    X = np.concatenate((data[1:-12], pred_1))
    y = np.concatenate((data[2:-12], pred_1, [real_1]))
    model.fit(X, y)
    pred_2 = model.predict([y[-1]])
    real_2 = data[-9]

    # Prediction 3
    X = np.concatenate((data[2:-12], pred_1, pred_2))
    y = np.concatenate((data[3:-12], pred_1, pred_2, [real_2]))
    model.fit(X, y)
    pred_3 = model.predict([y[-1]])
    real_3 = data[-8]
```

```
    # Prediction 4
    X = np.concatenate((data[3:-12], pred_1, pred_2, pred_3))
    y = np.concatenate((data[4:-12], pred_1, pred_2, pred_3, [real_3]))
    model.fit(X, y)
    pred_4 = model.predict([y[-1]])
    real_4 = data[-7]

    # Prediction 5
    X = np.concatenate((data[4:-12], pred_1, pred_2, pred_3, pred_4))
    y = np.concatenate((data[5:-12], pred_1, pred_2, pred_3, pred_4, [real_4]))
    model.fit(X, y)
    pred_5 = model.predict([y[-1]])
    real_5 = data[-6]

    # Prediction 6
    X = np.concatenate((data[5:-12], pred_1, pred_2, pred_3, pred_4, pred_5))
    y = np.concatenate((data[6:-12], pred_1, pred_2, pred_3, pred_4, pred_5, [real_5]))
    model.fit(X, y)
    pred_6 = model.predict([y[-1]])
    real_6 = data[-5]

    # Prediction 7
    X = np.concatenate((data[6:-12], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6))
    y = np.concatenate((data[7:-12], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, [real_6]))
    model.fit(X, y)
    pred_7 = model.predict([y[-1]])
    real_7 = data[-4]

    # Prediction 8
    X = np.concatenate((data[7:-12], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7))
    y = np.concatenate((data[8:-12], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, [real_7]))
    model.fit(X, y)
    pred_8 = model.predict([y[-1]])
    real_8 = data[-3]

    # Prediction 9
    X = np.concatenate((data[8:-12], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, pred_8))
    y = np.concatenate((data[9:-12], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, pred_8, [real_8]))
    model.fit(X, y)
```

```
    pred_9 = model.predict([y[-1]])
    real_9 = data[-2]

    # Prediction 10
    X = np.concatenate((data[9:-12], pred_1, pred_2, pred_3, pred_4, pred_5,␣
↪pred_6, pred_7, pred_8, pred_9))
    y = np.concatenate((data[10:-12], pred_1, pred_2, pred_3, pred_4, pred_5,␣
↪pred_6, pred_7, pred_8, pred_9, [real_9]))
    model.fit(X, y)
    pred_10 = model.predict([y[-1]])
    real_10 = data[-1]

    predictions = [l.tolist() for l in␣
↪[pred_1[0],pred_2[0],pred_3[0],pred_4[0],pred_5[0],pred_6[0],pred_7[0],pred_8[0],pred_9[0],
    real_values = [l.tolist() for l in␣
↪[real_1,real_2,real_3,real_4,real_5,real_6,real_7,real_8,real_9,real_10]]

    return predictions, real_values
```

[549]:
```
def plot_distance_errors(avg_distances):
    plt.plot(avg_distances)
    plt.title('Error en la predicción de posiciones')
    plt.ylabel('Distancia media')
    plt.xlabel('n predicción')
    plt.legend(['train', 'test'], loc='lower right')
    plt.show()
```

1.0.3 Test modelos de regresión

[550]:
```
# Linear regressor
from sklearn.linear_model import LinearRegression
model = LinearRegression()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 267.83609132206743
Time: 1.8150031566619873s
```

[551]:
```
# Ridge
from sklearn.linear_model import Ridge
model = Ridge()
start = time.time()
pred = get_results(model)
```

```python
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 24.12832157347379
Time: 0.9639983177185059s
```

[552]:
```python
# Lasso
import warnings
warnings.filterwarnings('ignore')
from sklearn.linear_model import Lasso
model = Lasso()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_error(pred)
print(f"Average error {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average error 0.0002535602550621559
Time: 1.2969977855682373s
```

[553]:
```python
# Lars
from sklearn.linear_model import Lars
model = Lars(n_nonzero_coefs=500, eps=0.5)
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 2.8608199417631064
Time: 1.773000955581665s
```

[554]:
```python
# LassoLars
from sklearn.linear_model import LassoLars
model = LassoLars()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 24.128459501029948
Time: 1.256000280380249s
```

[555]:
```
# MultiTaskElasticNet
from sklearn.linear_model import MultiTaskElasticNet
model = MultiTaskElasticNet()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 24.128459500669365
Time: 0.9019980430603027s
```

[556]:
```
# RANSACRegressor
from sklearn.linear_model import RANSACRegressor
model = RANSACRegressor()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 267.83609132206743
Time: 5.608991384506226s
```

[557]:
```
# DecisionTreeRegressor
from sklearn.tree import DecisionTreeRegressor
model = DecisionTreeRegressor()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 0.20931291022926427
Time: 0.7409956455230713s
```

[558]:
```
# ExtraTreeRegressor
from sklearn.tree import ExtraTreeRegressor
model = ExtraTreeRegressor()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 0.1936346509873833
Time: 0.7239949703216553s
```

[559]:
```
# MLPRegressor
from sklearn.neural_network import MLPRegressor
model = MLPRegressor(hidden_layer_sizes=100, activation='relu',␣
 ↪solver='lbfgs',alpha=0.001, learning_rate='adaptive', max_fun=10000)
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 16.88185766073174
Time: 7.0050153732299805s
```

[560]:
```
# KNeighborsRegressor
from sklearn.neighbors import KNeighborsRegressor
model = KNeighborsRegressor(n_neighbors=1)
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 0.022122681250334748
Time: 1.300994634628296s
```

[561]:
```
# RandomForestRegressor
from sklearn.ensemble import RandomForestRegressor
model = RandomForestRegressor(n_estimators=5)
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 1.5348190331825768
Time: 11.36794400215149s
```

[562]:
```
# BaggingRegressor
from sklearn.ensemble import BaggingRegressor
model = BaggingRegressor()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
```

```python
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 1.4010788705830168
Time: 25.740262508392334s
```

[563]:
```python
# GaussianProcessRegressor
from sklearn.gaussian_process import GaussianProcessRegressor
model = GaussianProcessRegressor()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

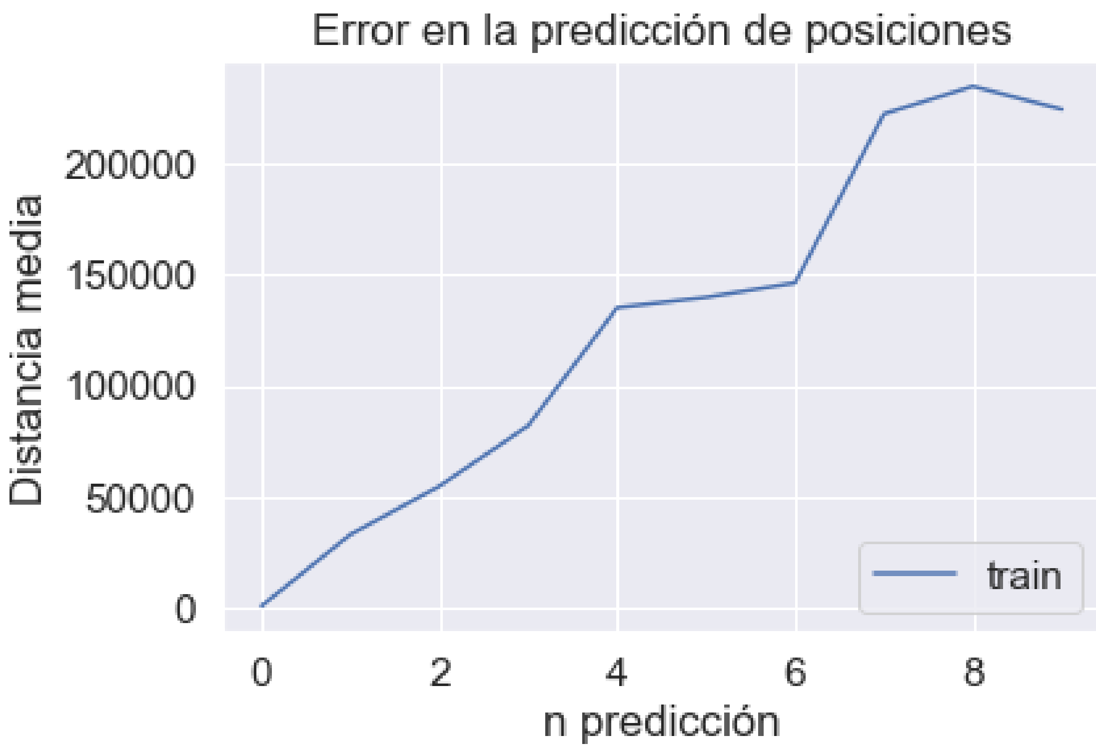
```
Average distance 2.930892974294869
Time: 2.759164571762085s
```

[564]:
```python
# DummyRegressor
from sklearn.dummy import DummyRegressor
model = DummyRegressor()
start = time.time()
pred = get_results(model)
avg_distance = get_avg_distance(pred)
print(f"Average distance {avg_distance}")
end = time.time()
print(f"Time: {end - start}s")
```

```
Average distance 24.128459501029948
Time: 0.17499732971191406s
```

1.0.4 Media de distancias en 10 predicciones

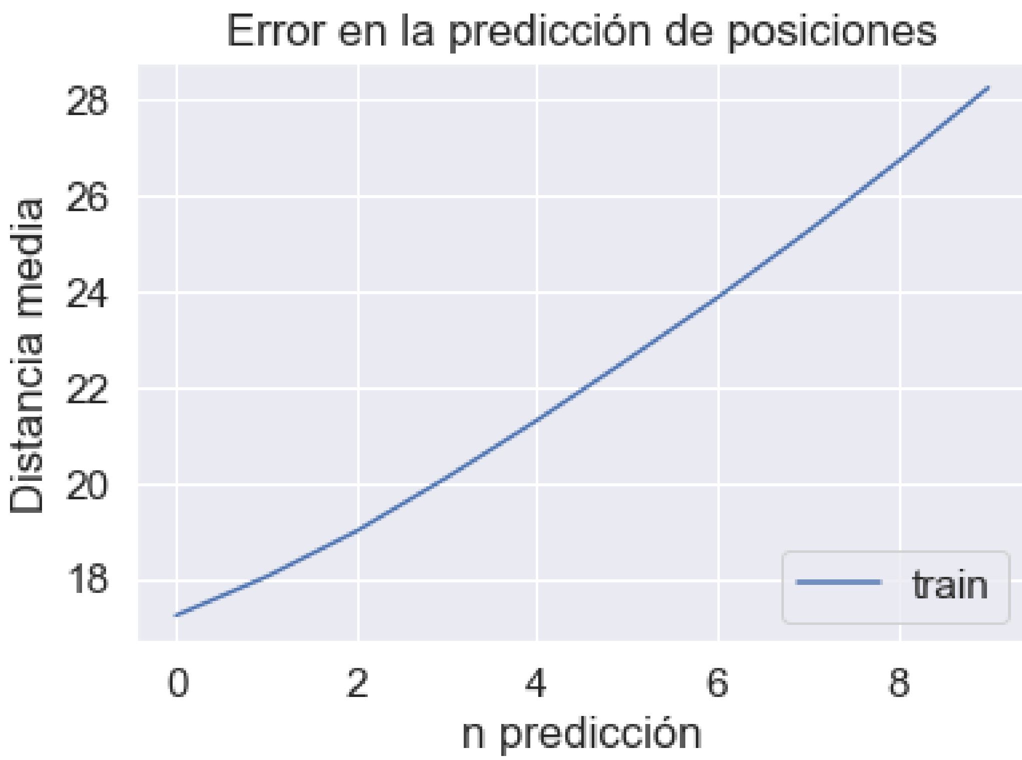
[565]:
```python
from sklearn.linear_model import LinearRegression
model = LinearRegression()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 746.963072935254
Average distance prediction 1: 32980.35856740886
Average distance prediction 2: 54730.10958604189
Average distance prediction 3: 82065.0060769803
Average distance prediction 4: 135219.9372630183
Average distance prediction 5: 139867.9908710348
Average distance prediction 6: 146365.60063533954
Average distance prediction 7: 222558.08287102802
Average distance prediction 8: 234986.66401311656
Average distance prediction 9: 224629.74598005554
```

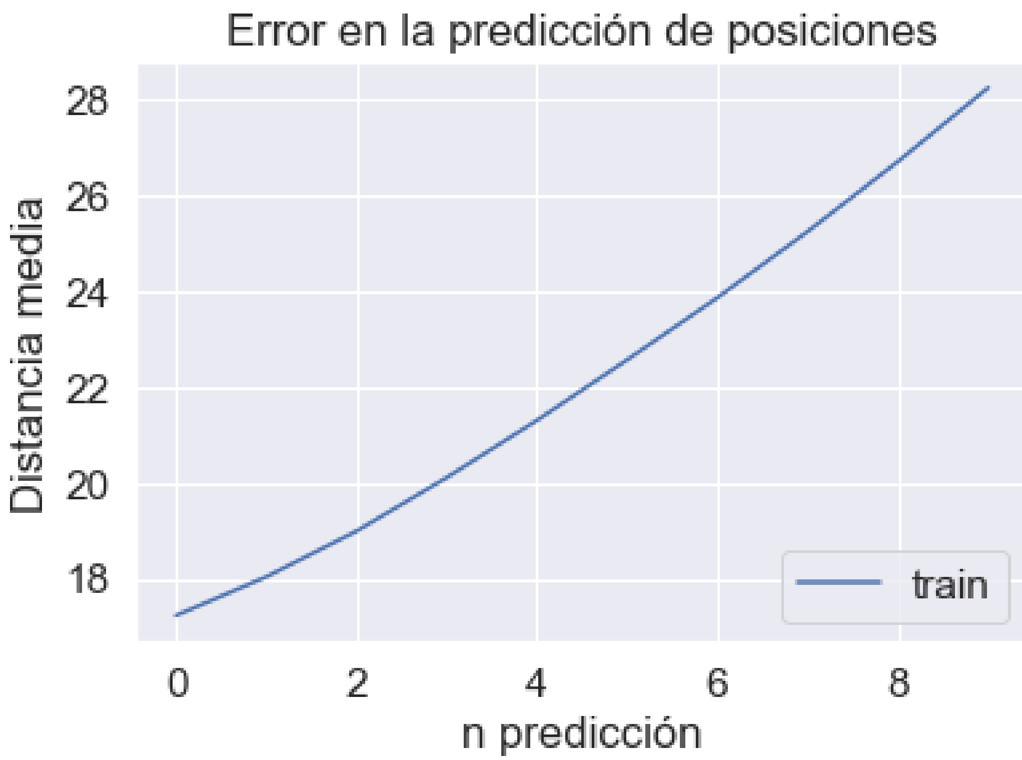
[566]:

```
# Ridge
from sklearn.linear_model import Ridge
model = Ridge()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```



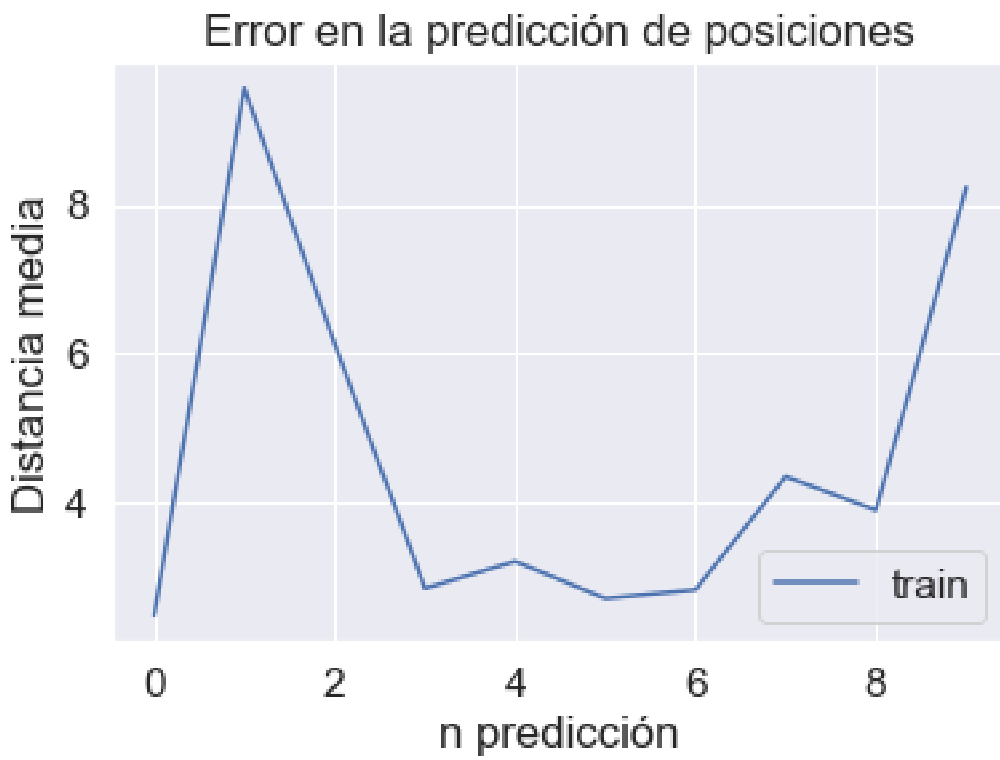

```
Average distance prediction 0: 17.22965741117776
Average distance prediction 1: 18.034240165239012
Average distance prediction 2: 18.986868303562794
Average distance prediction 3: 20.104405027476393
Average distance prediction 4: 21.29843845960165
Average distance prediction 5: 22.561778696542465
Average distance prediction 6: 23.857004634800823
Average distance prediction 7: 25.24111208237998
Average distance prediction 8: 26.697005550597627
Average distance prediction 9: 28.236189186807863
```

[567]:
```
# Lasso
import warnings
warnings.filterwarnings('ignore')
from sklearn.linear_model import Lasso
model = Lasso()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 17.22967477896253
Average distance prediction 1: 18.034254298398118
Average distance prediction 2: 18.986880910591964
Average distance prediction 3: 20.104416236887317
Average distance prediction 4: 21.29844855985368
Average distance prediction 5: 22.561788014849558
Average distance prediction 6: 23.857013526964483
Average distance prediction 7: 25.241120922598153
Average distance prediction 8: 26.69701472805039
Average distance prediction 9: 28.236199075512555
```

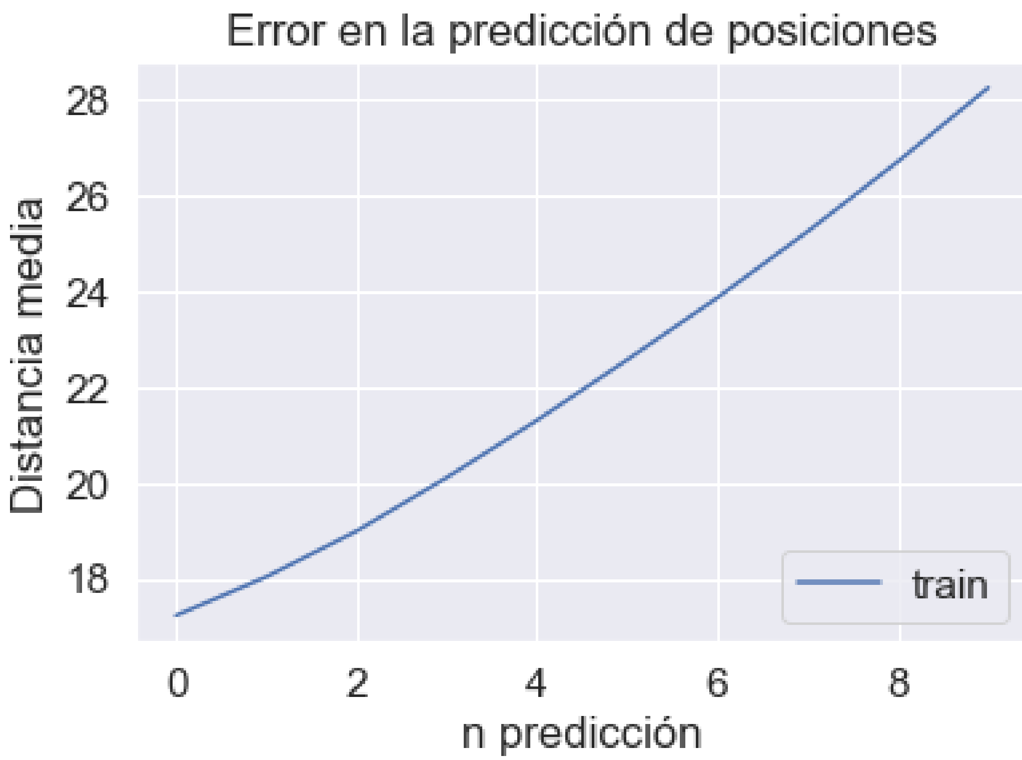
[568]:
```
# Lars
from sklearn.linear_model import Lars
model = Lars(n_nonzero_coefs=500, eps=0.5, )
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 2.490397814364312
Average distance prediction 1: 9.572126030119804
Average distance prediction 2: 6.145169121177993
Average distance prediction 3: 2.851976917419119
Average distance prediction 4: 3.2133575668954246
Average distance prediction 5: 2.7181701206898947
Average distance prediction 6: 2.834743463803702
Average distance prediction 7: 4.351860194122392
Average distance prediction 8: 3.901324746183364
Average distance prediction 9: 8.243856399359263
```

[569]:

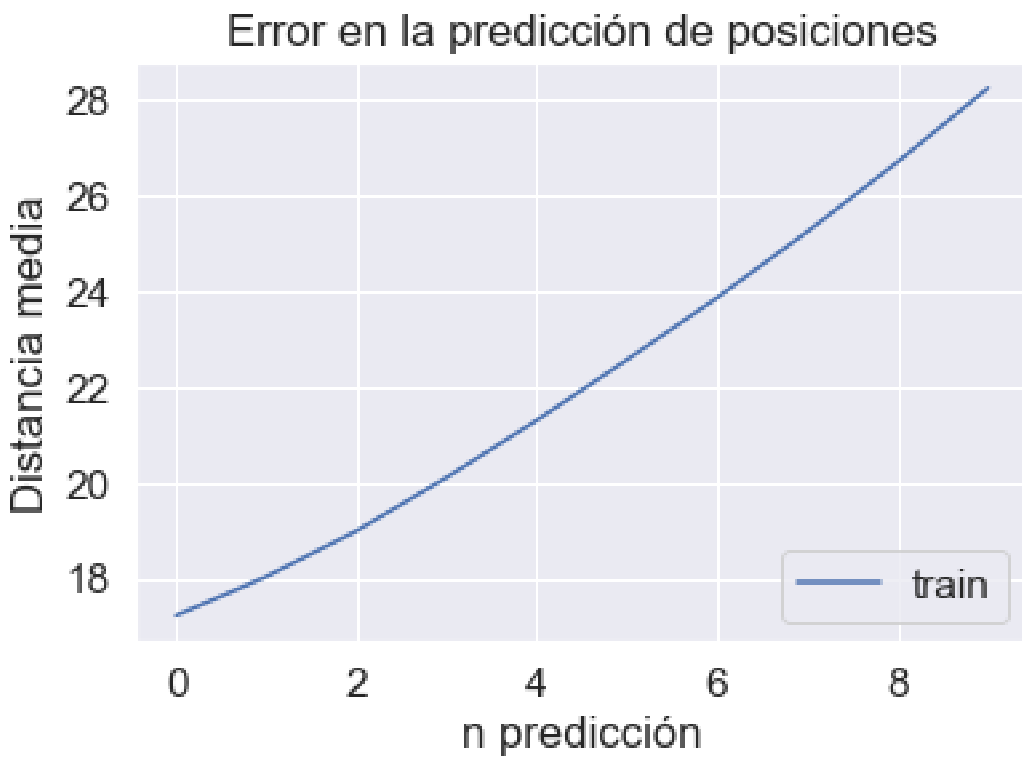
```
# LassoLars
from sklearn.linear_model import LassoLars
model = LassoLars()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 17.22967477899418
Average distance prediction 1: 18.034254298435823
Average distance prediction 2: 18.986880910625562
Average distance prediction 3: 20.10441623692093
Average distance prediction 4: 21.298448559876547
Average distance prediction 5: 22.561788014883906
Average distance prediction 6: 23.857013526960273
Average distance prediction 7: 25.241120922574325
Average distance prediction 8: 26.697014728059848
Average distance prediction 9: 28.236199075565224
```

[570]:

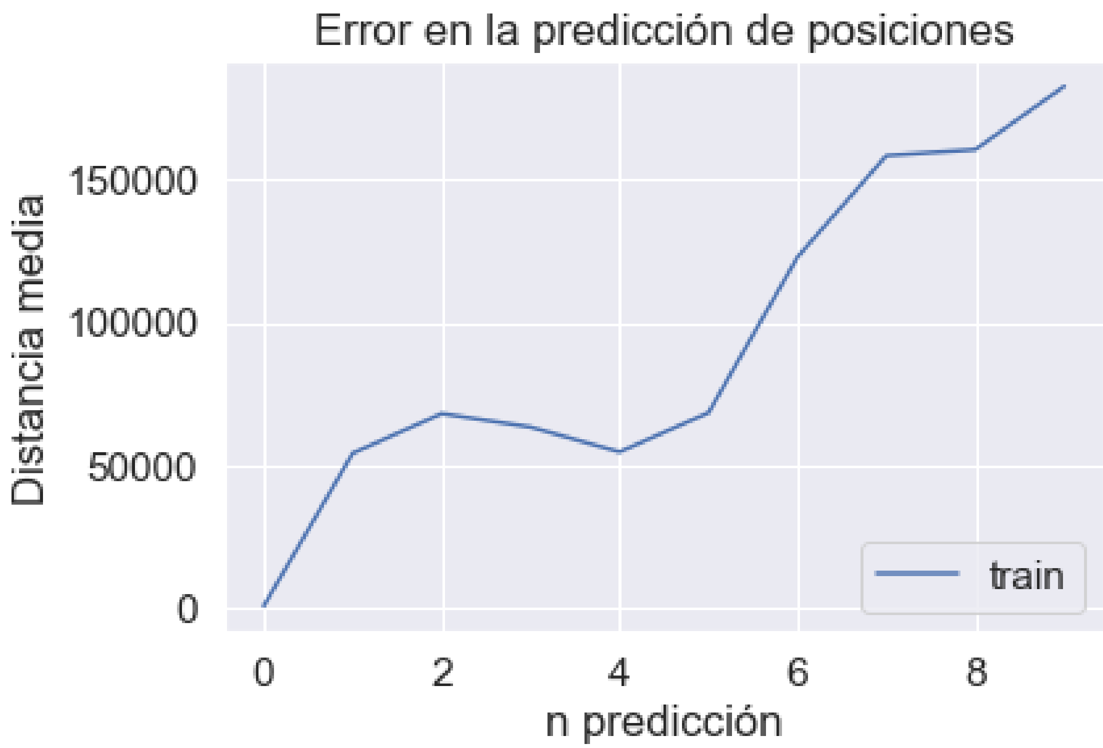
```
# MultiTaskElasticNet
from sklearn.linear_model import MultiTaskElasticNet
model = MultiTaskElasticNet()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 17.22967477896253
Average distance prediction 1: 18.034254298398118
Average distance prediction 2: 18.986880910591964
Average distance prediction 3: 20.104416236887317
Average distance prediction 4: 21.29844855985368
Average distance prediction 5: 22.561788014849558
Average distance prediction 6: 23.857013526964483
Average distance prediction 7: 25.241120922598153
Average distance prediction 8: 26.69701472805039
Average distance prediction 9: 28.236199075512555
```

[571]:

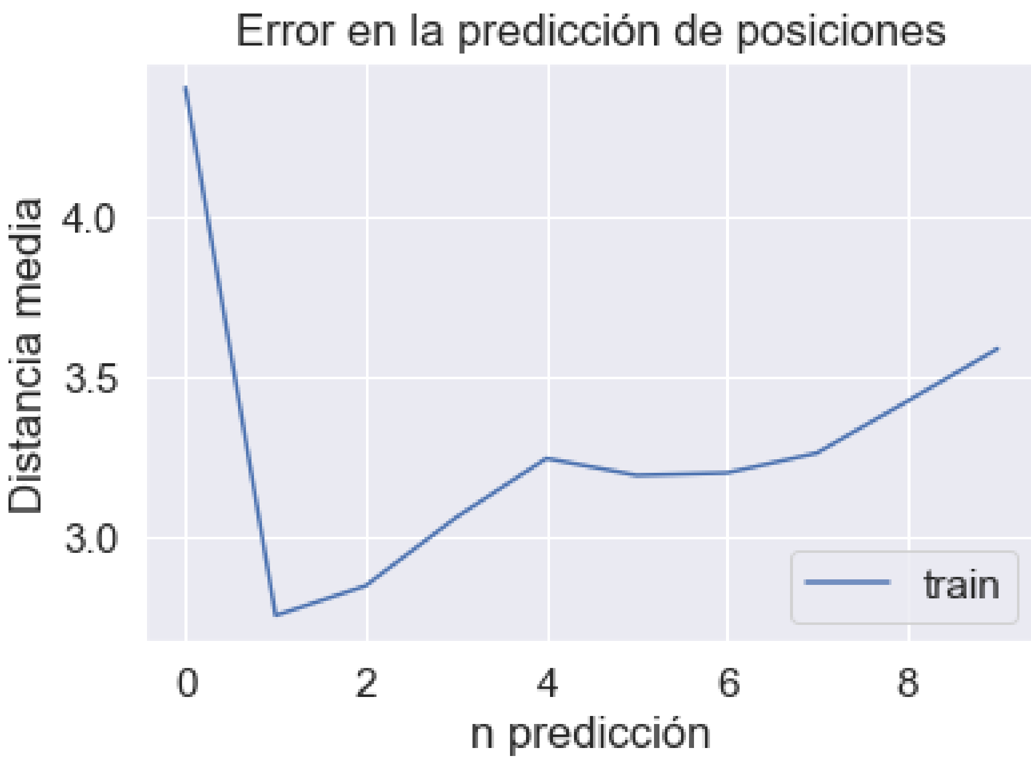
```
# RANSACRegressor
from sklearn.linear_model import RANSACRegressor
model = RANSACRegressor()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 746.9625153897573
Average distance prediction 1: 54237.016966768635
Average distance prediction 2: 68071.63674747136
Average distance prediction 3: 63352.54050726138
Average distance prediction 4: 54680.30924760415
Average distance prediction 5: 68370.78938748642
Average distance prediction 6: 122878.21123441048
Average distance prediction 7: 158436.37381497983
Average distance prediction 8: 160557.43941087913
Average distance prediction 9: 182694.1720816154
```

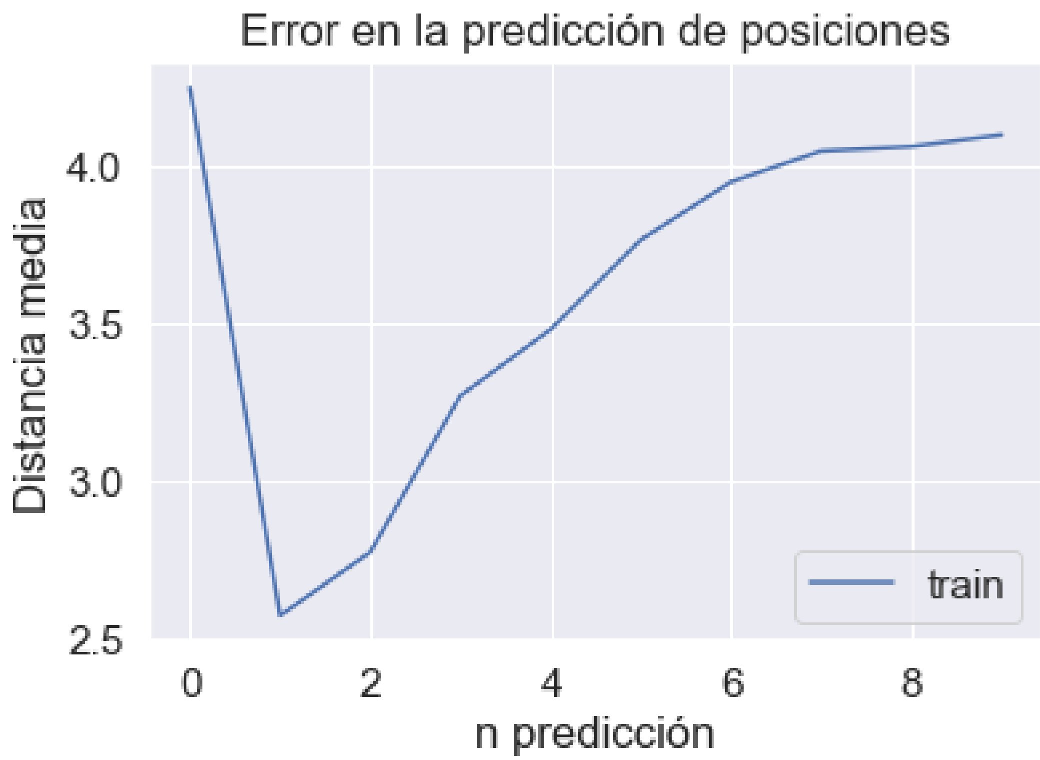
[572]:

```python
# DecisionTreeRegressor
from sklearn.tree import DecisionTreeRegressor
model = DecisionTreeRegressor()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```



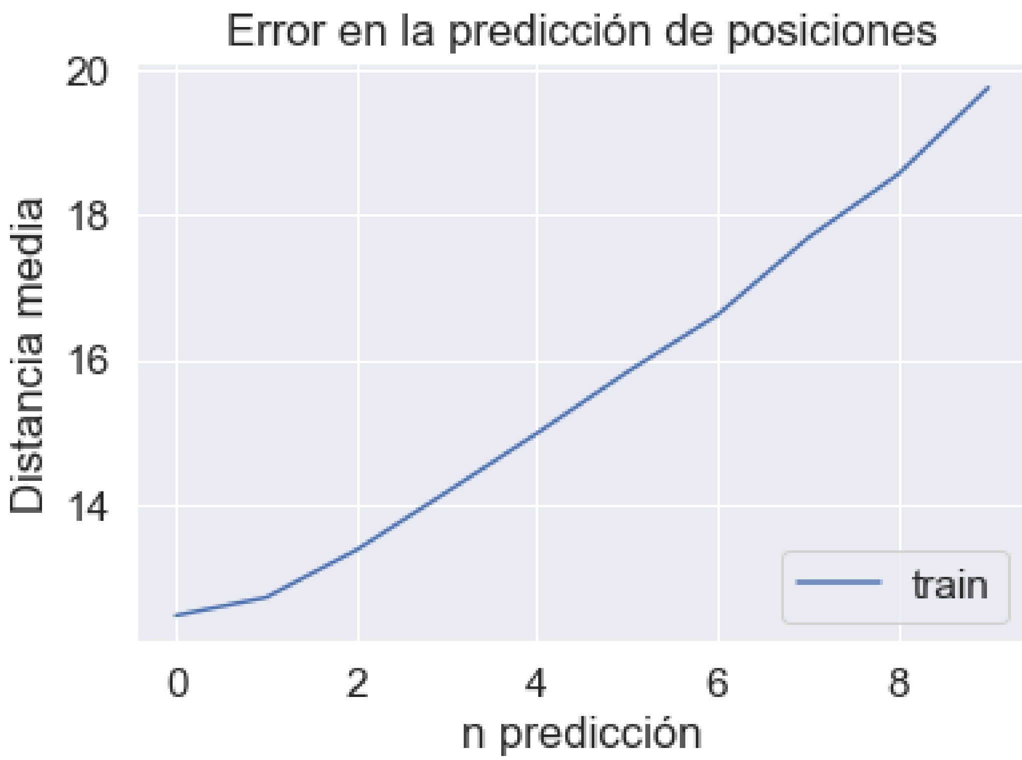

```
Average distance prediction 0: 4.401235111671969
Average distance prediction 1: 2.7595583926447436
Average distance prediction 2: 2.8522251542289236
Average distance prediction 3: 3.0639891098776797
Average distance prediction 4: 3.248108595168349
Average distance prediction 5: 3.195360285315973
Average distance prediction 6: 3.202830856137052
Average distance prediction 7: 3.264666587591404
Average distance prediction 8: 3.425822552599451
Average distance prediction 9: 3.5891731442798287
```

[573]:
```
# ExtraTreeRegressor
from sklearn.tree import ExtraTreeRegressor
model = ExtraTreeRegressor()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 4.250151546205461
Average distance prediction 1: 2.5711719383589986
Average distance prediction 2: 2.7721436575449947
Average distance prediction 3: 3.2696173719392236
Average distance prediction 4: 3.4807276631976642
Average distance prediction 5: 3.7659091114647154
Average distance prediction 6: 3.950379413580073
Average distance prediction 7: 4.0487888413698645
Average distance prediction 8: 4.063180047295977
Average distance prediction 9: 4.100316219759913
```

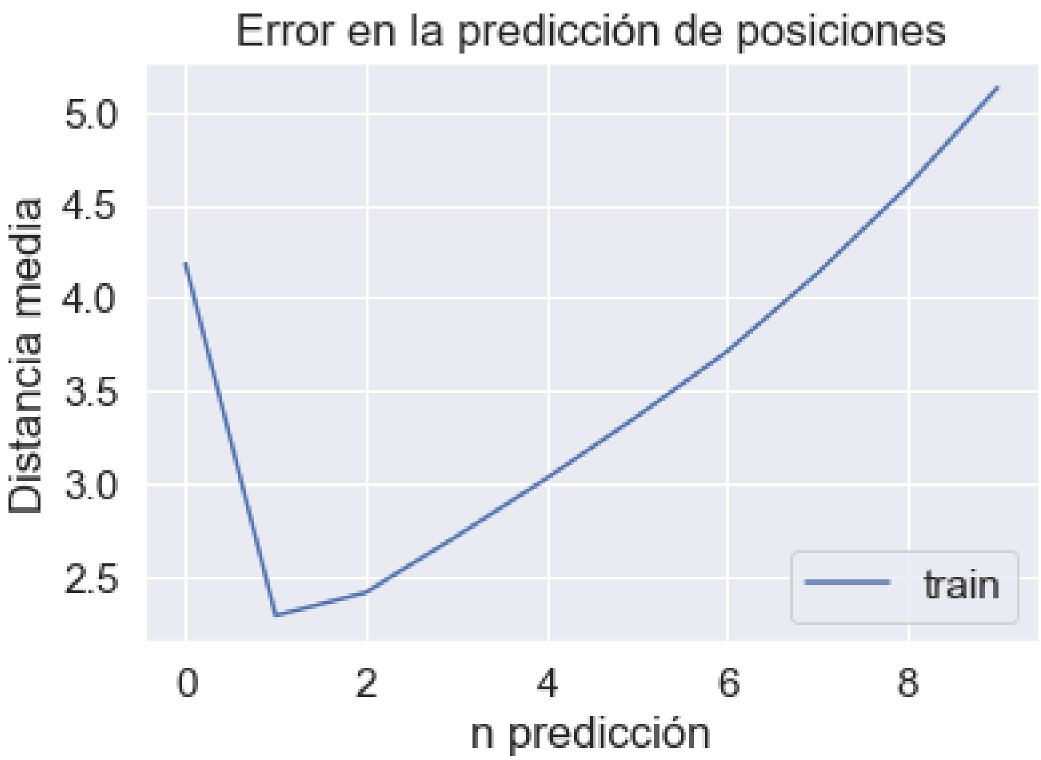
[574]:
```
# MLPRegressor
from sklearn.neural_network import MLPRegressor
model = MLPRegressor(hidden_layer_sizes=100, activation='relu',␣
 ↪solver='lbfgs',alpha=0.001, learning_rate='adaptive', max_fun=10000)
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 12.465900743327735
Average distance prediction 1: 12.716922046924067
Average distance prediction 2: 13.370140182564572
Average distance prediction 3: 14.17088626797173
Average distance prediction 4: 14.983127144636594
Average distance prediction 5: 15.830191720020078
Average distance prediction 6: 16.620066231656637
Average distance prediction 7: 17.683880791873342
Average distance prediction 8: 18.562157921658837
Average distance prediction 9: 19.76083553098903
```

[575]:

```
# KNeighborsRegressor
from sklearn.neighbors import KNeighborsRegressor
model = KNeighborsRegressor(n_neighbors=1)
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```



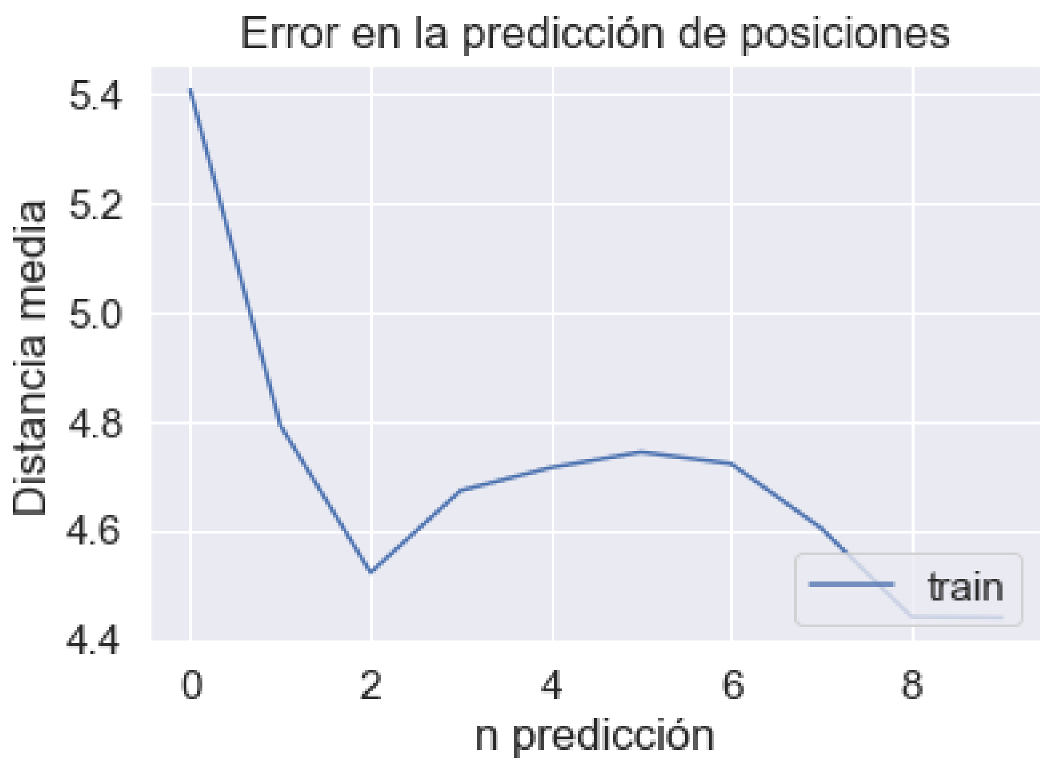

```
Average distance prediction 0: 4.183014630167164
Average distance prediction 1: 2.288490733581743
Average distance prediction 2: 2.4125395500691056
Average distance prediction 3: 2.711811372133221
Average distance prediction 4: 3.0250712856107205
Average distance prediction 5: 3.3570110403893008
Average distance prediction 6: 3.7075498826858837
Average distance prediction 7: 4.127609560308159
Average distance prediction 8: 4.596142147457087
Average distance prediction 9: 5.129526813103829
```

[576]:
```
'''# RandomForestRegressor
from sklearn.ensemble import RandomForestRegressor
model = RandomForestRegressor(n_estimators=5)
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")'''
```

[576]:
```
'# RandomForestRegressor\nfrom sklearn.ensemble import
RandomForestRegressor\nmodel = RandomForestRegressor(n_estimators=5)\npred, real
= call_get_next_10_predictions(X_set, model)\navg_distances =
```

```
get_avg_distance_10_predictions(pred,
real)\nplot_distance_errors(avg_distances)\nfor i in
range(len(avg_distances)):\n    print(f"Average distance prediction {i}:
{avg_distances[i]}")'
```

[577]:
```
# BaggingRegressor
from sklearn.ensemble import BaggingRegressor
model = BaggingRegressor()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 5.405870415947143
Average distance prediction 1: 4.791751185699113
Average distance prediction 2: 4.522194414104208
Average distance prediction 3: 4.672396885755094
Average distance prediction 4: 4.71449554797639
Average distance prediction 5: 4.742793085581139
Average distance prediction 6: 4.721606402134539
Average distance prediction 7: 4.603267796768419
Average distance prediction 8: 4.441288253379829
```

```
Average distance prediction 9: 4.439785708864413
```

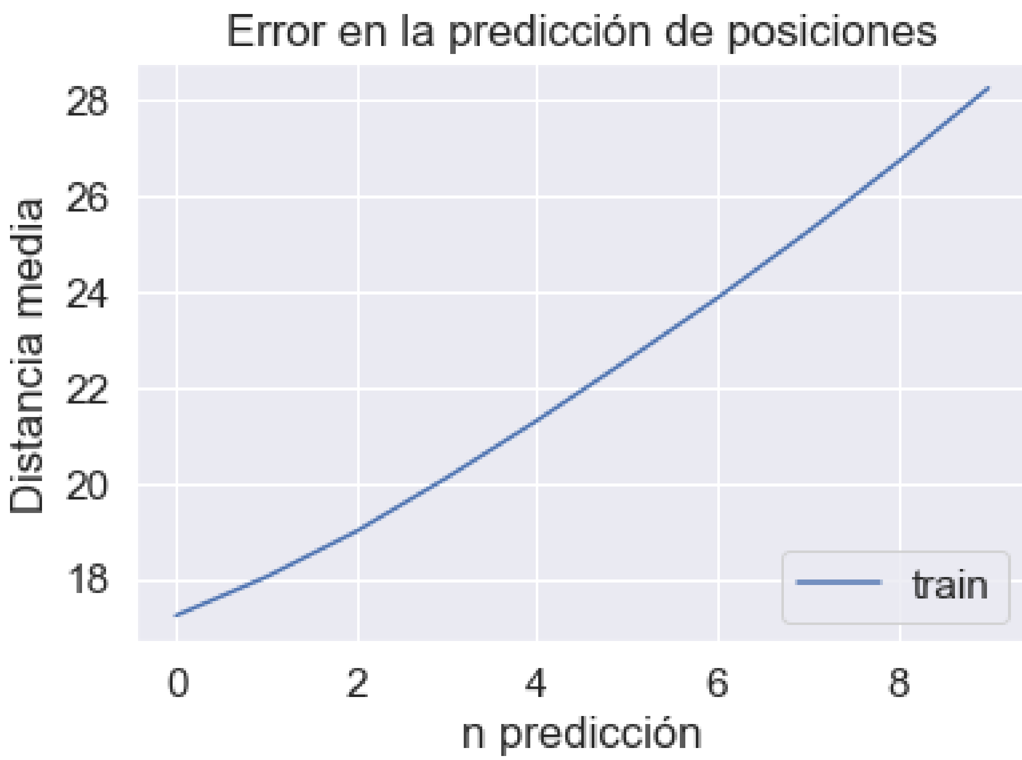
[578]:

```python
# GaussianProcessRegressor
from sklearn.gaussian_process import GaussianProcessRegressor
model = GaussianProcessRegressor()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```


```
Average distance prediction 0: 2.4035762407747074
Average distance prediction 1: 2.4789935089459245
Average distance prediction 2: 3.002679390803188
Average distance prediction 3: 2.615643318101096
Average distance prediction 4: 2.5906364462646922
Average distance prediction 5: 2.6706546342136415
Average distance prediction 6: 2.543070195044613
Average distance prediction 7: 2.645207795064917
Average distance prediction 8: 2.9015549450656284
Average distance prediction 9: 3.118560610608869
```

[579]:

```python
# DummyRegressor
from sklearn.dummy import DummyRegressor
model = DummyRegressor()
pred, real = call_get_next_10_predictions(X_set, model)
avg_distances = get_avg_distance_10_predictions(pred, real)
plot_distance_errors(avg_distances)
for i in range(len(avg_distances)):
    print(f"Average distance prediction {i}: {avg_distances[i]}")
```




```
Average distance prediction 0: 17.22967477899418
Average distance prediction 1: 18.034254298435823
Average distance prediction 2: 18.986880910625562
Average distance prediction 3: 20.10441623692093
Average distance prediction 4: 21.298448559876547
Average distance prediction 5: 22.561788014883906
Average distance prediction 6: 23.857013526960273
Average distance prediction 7: 25.241120922574325
Average distance prediction 8: 26.697014728059848
Average distance prediction 9: 28.236199075565224
```

2 Modelo MLP

2.0.1 Creación del dataset

[580]:
```
df = pd.read_csv("positions_1000.csv")
```

[581]:
```
def format_dataset(df, n):

    df = df.sort_values(['vehicle_id', 'time'])
    df = df.reset_index(drop=True)

    data = []
    temp_data = []
    temp_i = 0
    temp_vehicle = df.loc[0, 'vehicle_id']

    for i in range(1, df.shape[0]):

        row = df.loc[i]

        if row["vehicle_id"] != temp_vehicle:
            temp_vehicle = row["vehicle_id"]
            temp_i = 0
            temp_data = []
            temp_data.append(row["latitude"])
            temp_data.append(row["longitude"])

        elif temp_i < n:
            temp_data.append(row["latitude"])
            temp_data.append(row["longitude"])

        else:
            temp_data.append(row["latitude"])
            temp_data.append(row["longitude"])
            data.append(temp_data)
            temp_data = []
            temp_i = 0
            temp_vehicle = -1
        temp_i += 1

    #X = np.array(X, dtype='float64')
    #y = np.array(y, dtype='float64')

    return data

#mlp_data = format_dataset(df, 24)
```

[582]:
```
columns  = ["lat_0", "long_0", "lat_1", "long_1", "lat_2", "long_2", "lat_3",␣
↪"long_3", "lat_4", "long_4",
             "lat_5", "long_5", "lat_6", "long_6", "lat_7", "long_7", "lat_8",␣
↪"long_8", "lat_9", "long_9",
            "lat_10", "long_10", "lat_11", "long_11", "lat_12", "long_12",␣
↪"lat_13", "long_13", "lat_14", "long_14",
            "lat_15", "long_15", "lat_16", "long_16", "lat_17", "long_17",␣
↪"lat_18", "long_18", "lat_19", "long_19",
            "lat_20", "long_20", "lat_21", "long_21", "lat_22", "long_22",␣
↪"lat_23", "long_23", "lat_24", "long_24"]
```

[583]:
```
#df_mlp = pd.DataFrame(mlp_data, columns=columns )
```

[584]:
```
#df_mlp.to_csv("df_mlp_19.csv")
```

2.0.2 Preparación de datos

[585]:
```
df_mlp = pd.read_csv("df_mlp_24.csv")
```

[586]:
```
len(df_mlp)
```

[586]: 151099

[587]:
```
#df_mlp = df_mlp.loc[(df_mlp["lat_0"]!=df_mlp["lat_1"]) & (df_mlp["long_0"]!
↪=df_mlp["long_1"])]
```

[588]:
```
df_mlp = df_mlp.drop(["Unnamed: 0"], axis=1)
```

[589]:
```
y_mlp = df_mlp[["lat_15", "long_15", "lat_16", "long_16", "lat_17", "long_17",␣
↪"lat_18", "long_18", "lat_19", "long_19","lat_20", "long_20", "lat_21",␣
↪"long_21", "lat_22", "long_22", "lat_23", "long_23", "lat_24", "long_24"]]
X_mlp = df_mlp#.drop(["lat_15", "long_15"], axis=1)
```

[590]:
```
df_mlp
```

[590]:

	lat_0	long_0	lat_1	long_1	lat_2	long_2 \
0	41.390949	2.163105	41.390879	2.163014	41.390819	2.162934
1	41.389290	2.160920	41.389221	2.160824	41.389154	2.160731
2	41.390644	2.167087	41.390662	2.167065	41.390679	2.167043
3	41.391037	2.166599	41.391053	2.166580	41.391060	2.166572
4	41.391187	2.166414	41.391198	2.166400	41.391202	2.166396
…	…	…	…	…	…	…
151094	41.389972	2.162020	41.389963	2.162007	41.389962	2.162005
151095	41.393290	2.163255	41.393283	2.163263	41.393271	2.163279
151096	41.391992	2.162036	41.391979	2.162054	41.391945	2.162100
151097	41.390042	2.161647	41.390052	2.161697	41.390035	2.161731
151098	41.390493	2.166997	41.390525	2.167009	41.390546	2.166983

```
           lat_3    long_3      lat_4    long_4  …     lat_20   long_20  \
0       41.390756  2.162850  41.390692  2.162765  …  41.389624  2.161361
1       41.389091  2.160646  41.389025  2.160558  …  41.387971  2.159163
2       41.390698  2.167020  41.390716  2.166998  …  41.390991  2.166657
3       41.391072  2.166556  41.391081  2.166545  …  41.391138  2.166475
4       41.391206  2.166391  41.391214  2.166380  …  41.391243  2.166345
…             …         …          …         …  …          …
151094  41.389945  2.161984  41.389910  2.161949  …  41.389313  2.162742
151095  41.393256  2.163297  41.393245  2.163311  …  41.393085  2.163511
151096  41.391890  2.162176  41.391832  2.162255  …  41.391231  2.163095
151097  41.390032  2.161738  41.390031  2.161740  …  41.390030  2.161742
151098  41.390599  2.166971  41.390638  2.166922  …  41.391396  2.166175

          lat_21   long_21     lat_22   long_22     lat_23   long_23  \
0       41.389556  2.161278  41.389495  2.161201  41.389422  2.161102
1       41.387898  2.159066  41.387827  2.158973  41.387761  2.158886
2       41.390997  2.166650  41.391008  2.166636  41.391020  2.166621
3       41.391147  2.166463  41.391155  2.166453  41.391161  2.166447
4       41.391243  2.166345  41.391243  2.166345  41.391243  2.166345
…             …         …          …         …          …         …
151094  41.389249  2.162826  41.389188  2.162906  41.389162  2.162940
151095  41.393077  2.163521  41.393065  2.163536  41.393060  2.163542
151096  41.391231  2.163095  41.391231  2.163095  41.391231  2.163095
151097  41.390030  2.161742  41.390030  2.161742  41.390030  2.161742
151098  41.391454  2.166219  41.391500  2.166270  41.391540  2.166324

          lat_24   long_24
0       41.389358  2.161013
1       41.387690  2.158791
2       41.391035  2.166602
3       41.391170  2.166435
4       41.391243  2.166345
…             …         …
151094  41.389155  2.162950
151095  41.393060  2.163542
151096  41.391231  2.163095
151097  41.390030  2.161742
151098  41.391580  2.166376

[151099 rows x 50 columns]
```

2.0.3 Estandarización

[591]:
```
X_mlp_train_full, X_mlp_test_full, y_mlp_train_full, y_mlp_test_full =␣
↪train_test_split(X_mlp, y_mlp, test_size=0.25, random_state=42)
print(f"Shape X_mlp_train: {X_mlp_train_full.shape}")
print(f"Shape X_mlp_test: {X_mlp_test_full.shape}")
print(f"Shape y_mlp_train: {y_mlp_train_full.shape}")
print(f"Shape y_mlp_test: {y_mlp_test_full.shape}")
```

```
Shape X_mlp_train: (113324, 50)
Shape X_mlp_test: (37775, 50)
Shape y_mlp_train: (113324, 20)
Shape y_mlp_test: (37775, 20)
```

[592]:
```
y_aaa = y_mlp_train_full[["lat_15", "long_15"]]
y_aaaa = y_mlp_test_full[["lat_15", "long_15"]]
print(f"Shape X_mlp_train: {X_mlp_train_full.shape}")
print(f"Shape X_mlp_test: {X_mlp_test_full.shape}")
print(f"Shape y_mlp_train: {y_aaa.shape}")
print(f"Shape y_mlp_test: {y_aaaa.shape}")
```

```
Shape X_mlp_train: (113324, 50)
Shape X_mlp_test: (37775, 50)
Shape y_mlp_train: (113324, 2)
Shape y_mlp_test: (37775, 2)
```

[593]:
```
#Normalizar los datos
X_mlp_train = X_mlp_train_full.drop(["lat_15", "long_15", "lat_16", "long_16",␣
↪"lat_17", "long_17", "lat_18", "long_18", "lat_19", "long_19", "lat_20",␣
↪"long_20", "lat_21", "long_21", "lat_22", "long_22", "lat_23", "long_23",␣
↪"lat_24", "long_24"], axis=1)
X_mlp_test = X_mlp_test_full.drop(["lat_15", "long_15", "lat_16", "long_16",␣
↪"lat_17", "long_17", "lat_18", "long_18", "lat_19", "long_19", "lat_20",␣
↪"long_20", "lat_21", "long_21", "lat_22", "long_22", "lat_23", "long_23",␣
↪"lat_24", "long_24"], axis=1)
scaler = StandardScaler().fit(X_mlp_train)
X_mlp_train = scaler.transform(X_mlp_train)
X_mlp_test = scaler.transform(X_mlp_test)


y_mlp_lat_train_full = y_mlp_train_full[["lat_15", "lat_16", "lat_17",␣
↪"lat_18", "lat_19", "lat_20", "long_20", "lat_21", "long_21", "lat_22",␣
↪"long_22", "lat_23", "long_23", "lat_24", "long_24"]]
y_mlp_lat_test_full = y_mlp_test_full[["lat_15", "lat_16", "lat_17", "lat_18",␣
↪"lat_19", "lat_20", "long_20", "lat_21", "long_21", "lat_22", "long_22",␣
↪"lat_23", "long_23", "lat_24", "long_24"]]

scaler_lat = StandardScaler().fit(y_mlp_lat_train_full[["lat_15"]])
```

```
y_mlp_lat_train = y_mlp_lat_train_full[["lat_15"]]
y_mlp_lat_test = y_mlp_lat_test_full[["lat_15"]]
y_mlp_lat_train = scaler_lat.transform(y_mlp_lat_train)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)


y_mlp_long_train_full = y_mlp_train_full[["long_15", "long_16", "long_17",␣
↪"long_18", "long_19", "lat_20", "long_20", "lat_21", "long_21", "lat_22",␣
↪"long_22", "lat_23", "long_23", "lat_24", "long_24"]]
y_mlp_long_test_full = y_mlp_test_full[["long_15", "long_16", "long_17",␣
↪"long_18", "long_19", "lat_20", "long_20", "lat_21", "long_21", "lat_22",␣
↪"long_22", "lat_23", "long_23", "lat_24", "long_24"]]

scaler_long = StandardScaler().fit(y_mlp_long_train_full[["long_15"]])
y_mlp_long_train = y_mlp_long_train_full[["long_15"]]
y_mlp_long_test = y_mlp_long_test_full[["long_15"]]
y_mlp_long_train = scaler_long.transform(y_mlp_long_train)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)
```

[594]:
```
X_mlp_train[0]
```

[594]:
```
array([-0.30641891,  0.84317902, -0.2693146 ,  0.88302696, -0.24177196,
        0.91256045, -0.21146159,  0.94512487, -0.18062133,  0.97863912,
       -0.15183434,  1.01042493, -0.12507448,  1.03944564, -0.09318535,
        1.06658539, -0.05707962,  1.09669166, -0.02498172,  1.12365827,
        0.01568591,  1.14410806,  0.05051164,  1.15940871,  0.09024261,
        1.16088545,  0.1201988 ,  1.15258728,  0.13562245,  1.14461973])
```

2.0.4 Modelo

[595]:
```
model_mlp_lat = Sequential([
    Flatten(input_shape=[X_mlp_train.shape[1],]),
    Dense(128, activation="relu", kernel_initializer="normal"),
    Dropout(0.1),
    Dense(64, activation="tanh", kernel_initializer="normal"),
    Dropout(0.2),
    Dense(16, activation="tanh", kernel_initializer="normal"),
    Dropout(0.2),
    Dense(1, activation="linear")
])
```

[596]:
```
model_mlp_long = Sequential([
    Flatten(input_shape=[X_mlp_train.shape[1],]),
    Dense(128, activation="relu", kernel_initializer="normal"),
    Dropout(0.2),
    Dense(64, activation="tanh", kernel_initializer="normal"),
    Dropout(0.2),
```

```python
    Dense(16, activation="tanh", kernel_initializer="normal"),
    Dropout(0.2),
    Dense(1, activation="linear")
])
```

[597]:
```python
model_mlp_lat.summary()
```

```
Model: "sequential"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten (Flatten)           (None, 30)                0

 dense (Dense)               (None, 128)               3968

 dropout (Dropout)           (None, 128)               0

 dense_1 (Dense)             (None, 64)                8256

 dropout_1 (Dropout)         (None, 64)                0

 dense_2 (Dense)             (None, 16)                1040

 dropout_2 (Dropout)         (None, 16)                0

 dense_3 (Dense)             (None, 1)                 17

=================================================================
Total params: 13,281
Trainable params: 13,281
Non-trainable params: 0
_________________________________________________________________
```

[598]:
```python
model_mlp_long.summary()
```

```
Model: "sequential_1"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten_1 (Flatten)         (None, 30)                0

 dense_4 (Dense)             (None, 128)               3968

 dropout_3 (Dropout)         (None, 128)               0

 dense_5 (Dense)             (None, 64)                8256

 dropout_4 (Dropout)         (None, 64)                0
```

```
 dense_6 (Dense)             (None, 16)                1040

 dropout_5 (Dropout)         (None, 16)                0

 dense_7 (Dense)             (None, 1)                 17

=================================================================
Total params: 13,281
Trainable params: 13,281
Non-trainable params: 0
_________________________________________________________________
```

2.0.5 Cálculo latitud

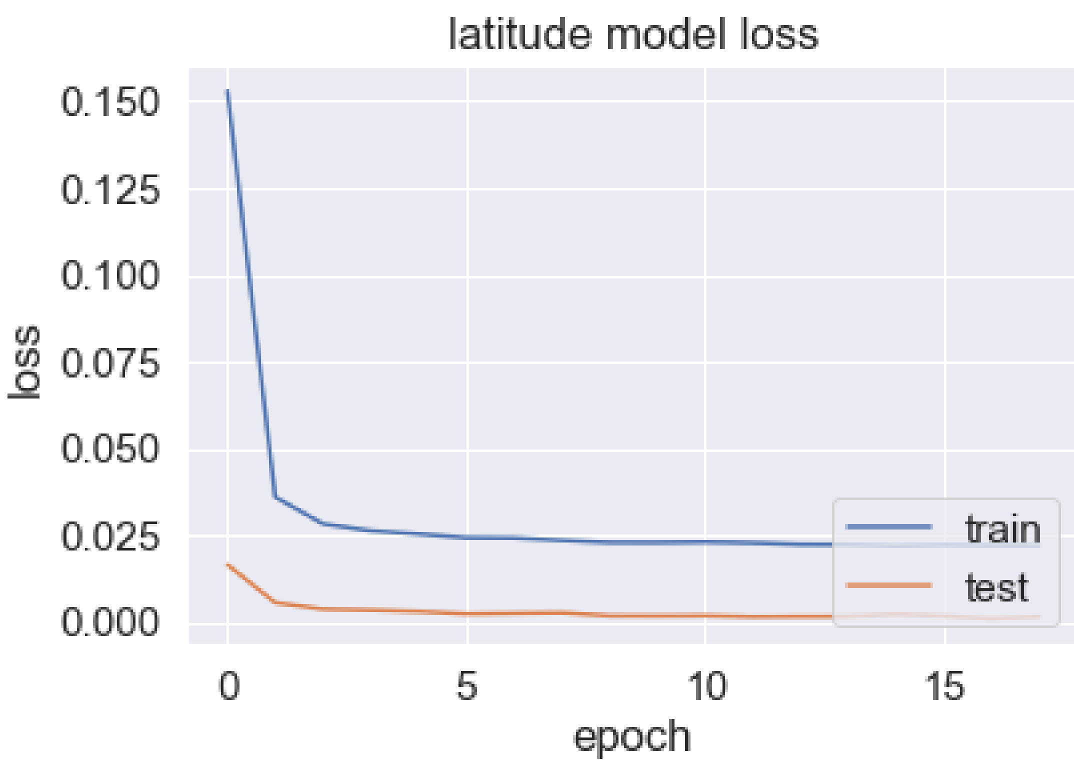
[599]:
```
epochs = 18
batch_size = 256
optimizer = Adam(learning_rate=0.0001)
model_mlp_lat.compile(loss='mse', optimizer=optimizer)
history = model_mlp_lat.fit(X_mlp_train, y_mlp_lat_train, epochs=epochs,␣
 ↪batch_size=batch_size, validation_data=(X_mlp_test, y_mlp_lat_test),␣
 ↪verbose=1)
model_mlp_lat.summary()
```

```
Epoch 1/18
WARNING:tensorflow:AutoGraph could not transform <function
Model.make_train_function.<locals>.train_function at 0x000002E0C251F0D0> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function
Model.make_train_function.<locals>.train_function at 0x000002E0C251F0D0> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
439/443 [============================>.] - ETA: 0s - loss:
0.1537WARNING:tensorflow:AutoGraph could not transform <function
Model.make_test_function.<locals>.test_function at 0x000002E0C0ABDA60> and will
```

```
run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function
Model.make_test_function.<locals>.test_function at 0x000002E0C0ABDA60> and will
run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
443/443 [==============================] - 6s 10ms/step - loss: 0.1528 -
val_loss: 0.0164
Epoch 2/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0359 -
val_loss: 0.0055
Epoch 3/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0282 -
val_loss: 0.0037
Epoch 4/18
443/443 [==============================] - 3s 6ms/step - loss: 0.0262 -
val_loss: 0.0034
Epoch 5/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0253 -
val_loss: 0.0030
Epoch 6/18
443/443 [==============================] - 2s 4ms/step - loss: 0.0242 -
val_loss: 0.0023
Epoch 7/18
443/443 [==============================] - 2s 4ms/step - loss: 0.0241 -
val_loss: 0.0025
Epoch 8/18
443/443 [==============================] - 2s 4ms/step - loss: 0.0234 -
val_loss: 0.0026
Epoch 9/18
443/443 [==============================] - 2s 4ms/step - loss: 0.0228 -
val_loss: 0.0017
Epoch 10/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0228 -
val_loss: 0.0017
Epoch 11/18
```

```
443/443 [==============================] - 3s 6ms/step - loss: 0.0230 -
val_loss: 0.0018
Epoch 12/18
443/443 [==============================] - 3s 7ms/step - loss: 0.0227 -
val_loss: 0.0015
Epoch 13/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0222 -
val_loss: 0.0015
Epoch 14/18
443/443 [==============================] - 2s 6ms/step - loss: 0.0222 -
val_loss: 0.0016
Epoch 15/18
443/443 [==============================] - 3s 6ms/step - loss: 0.0218 -
val_loss: 0.0022
Epoch 16/18
443/443 [==============================] - 3s 6ms/step - loss: 0.0221 -
val_loss: 0.0017
Epoch 17/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0219 -
val_loss: 9.2416e-04
Epoch 18/18
443/443 [==============================] - 3s 6ms/step - loss: 0.0219 -
val_loss: 0.0015
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten (Flatten)           (None, 30)                0

 dense (Dense)               (None, 128)               3968

 dropout (Dropout)           (None, 128)               0

 dense_1 (Dense)             (None, 64)                8256

 dropout_1 (Dropout)         (None, 64)                0

 dense_2 (Dense)             (None, 16)                1040

 dropout_2 (Dropout)         (None, 16)                0

 dense_3 (Dense)             (None, 1)                 17

=================================================================
Total params: 13,281
Trainable params: 13,281
Non-trainable params: 0
_________________________________________________________________
```

[600]:
```
#Plots
%matplotlib inline

# Visualizamos la evolución de la accuracy
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('latitude model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='lower right')
plt.show()
```



[601]:
```
y_lat_pred = model_mlp_lat.predict(X_mlp_test[0:1000])
y_lat_pred = scaler_lat.inverse_transform(y_lat_pred)
y_lat_real = scaler_lat.inverse_transform(y_mlp_lat_test)
```

```
WARNING:tensorflow:AutoGraph could not transform <function
Model.make_predict_function.<locals>.predict_function at 0x000002E0BEDA0700> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
```

```
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function
Model.make_predict_function.<locals>.predict_function at 0x000002E0BEDA0700> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
```

[602]:
```
print(y_lat_pred[0:10])
print(y_lat_real[0:10])
```

```
[[41.391293]
 [41.390358]
 [41.393314]
 [41.389812]
 [41.392044]
 [41.390003]
 [41.390022]
 [41.390747]
 [41.39087 ]
 [41.392483]]
[[41.39128345]
 [41.3903562 ]
 [41.39332725]
 [41.38976118]
 [41.39206235]
 [41.38996487]
 [41.38994085]
 [41.3906968 ]
 [41.3908445 ]
 [41.39248576]]
```

2.0.6 Cálculo longitud

[603]:
```
epochs = 18
batch_size = 256
optimizer = Adam(learning_rate=0.0001)
model_mlp_long.compile(loss='mse', optimizer=optimizer)
history = model_mlp_long.fit(X_mlp_train, y_mlp_long_train, epochs=epochs,␣
 ↪batch_size=batch_size, validation_data=(X_mlp_test, y_mlp_long_test),␣
 ↪verbose=1)
model_mlp_long.summary()
```

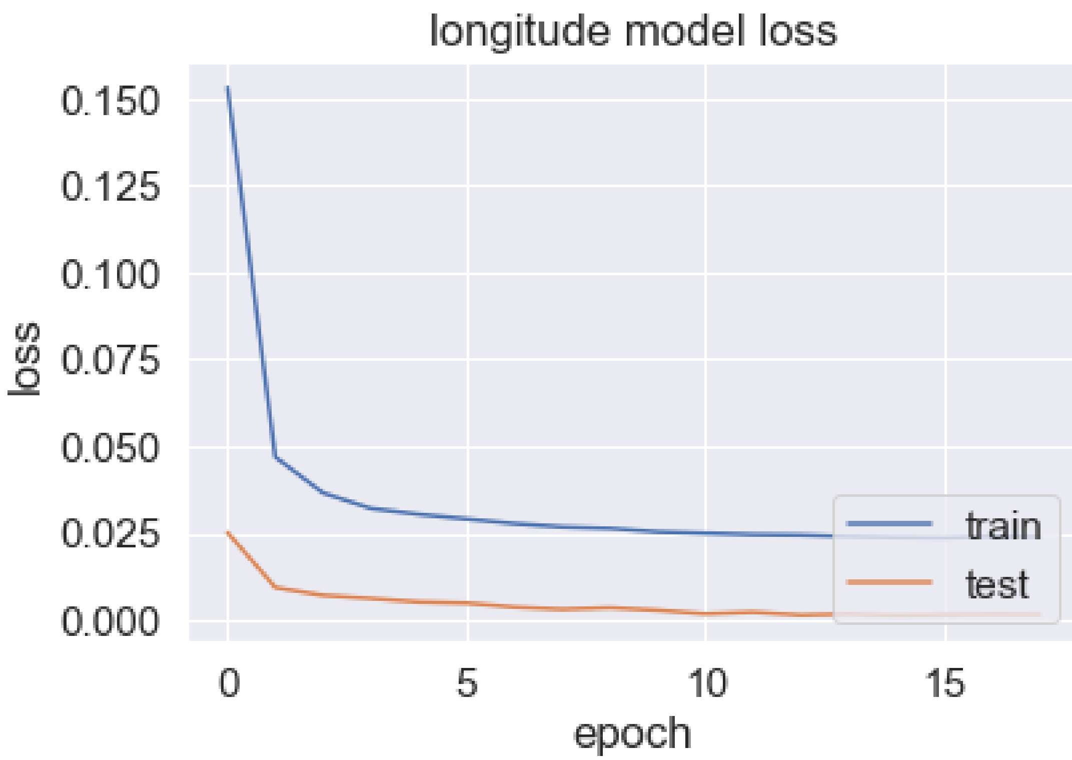
```
Epoch 1/18
WARNING:tensorflow:AutoGraph could not transform <function
Model.make_train_function.<locals>.train_function at 0x000002E0C22ABD30> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function
Model.make_train_function.<locals>.train_function at 0x000002E0C22ABD30> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
432/443 [============================>.] - ETA: 0s - loss:
0.1554WARNING:tensorflow:AutoGraph could not transform <function
Model.make_test_function.<locals>.test_function at 0x000002E0C002C280> and will
run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function
Model.make_test_function.<locals>.test_function at 0x000002E0C002C280> and will
run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
443/443 [==============================] - 3s 5ms/step - loss: 0.1531 -
val_loss: 0.0251
Epoch 2/18
443/443 [==============================] - 2s 4ms/step - loss: 0.0469 -
val_loss: 0.0094
Epoch 3/18
```

```
443/443 [==============================] - 2s 5ms/step - loss: 0.0365 -
val_loss: 0.0071
Epoch 4/18
443/443 [==============================] - 3s 7ms/step - loss: 0.0321 -
val_loss: 0.0062
Epoch 5/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0304 -
val_loss: 0.0052
Epoch 6/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0290 -
val_loss: 0.0049
Epoch 7/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0277 -
val_loss: 0.0037
Epoch 8/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0267 -
val_loss: 0.0031
Epoch 9/18
443/443 [==============================] - 3s 6ms/step - loss: 0.0263 -
val_loss: 0.0036
Epoch 10/18
443/443 [==============================] - 3s 7ms/step - loss: 0.0253 -
val_loss: 0.0028
Epoch 11/18
443/443 [==============================] - 3s 6ms/step - loss: 0.0249 -
val_loss: 0.0018
Epoch 12/18
443/443 [==============================] - 4s 9ms/step - loss: 0.0245 -
val_loss: 0.0023
Epoch 13/18
443/443 [==============================] - 3s 7ms/step - loss: 0.0244 -
val_loss: 0.0015
Epoch 14/18
443/443 [==============================] - 3s 6ms/step - loss: 0.0240 -
val_loss: 0.0018
Epoch 15/18
443/443 [==============================] - 3s 8ms/step - loss: 0.0237 -
val_loss: 0.0013
Epoch 16/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0236 -
val_loss: 0.0015
Epoch 17/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0240 -
val_loss: 0.0017
Epoch 18/18
443/443 [==============================] - 2s 5ms/step - loss: 0.0239 -
val_loss: 0.0016
Model: "sequential_1"
```

```
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten_1 (Flatten)         (None, 30)                0

 dense_4 (Dense)             (None, 128)               3968

 dropout_3 (Dropout)         (None, 128)               0

 dense_5 (Dense)             (None, 64)                8256

 dropout_4 (Dropout)         (None, 64)                0

 dense_6 (Dense)             (None, 16)                1040

 dropout_5 (Dropout)         (None, 16)                0

 dense_7 (Dense)             (None, 1)                 17

=================================================================
Total params: 13,281
Trainable params: 13,281
Non-trainable params: 0
_________________________________________________________________
```

[604]:

```
#Plots
%matplotlib inline
import matplotlib.pyplot as plt

# Visualizamos la evolución de la accuracy
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('longitude model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='lower right')
plt.show()
```



[605]:
```
y_long_pred = model_mlp_long.predict(X_mlp_test[0:1000])
y_long_pred = scaler_long.inverse_transform(y_long_pred)
y_long_real = scaler_long.inverse_transform(y_mlp_long_test)
print(y_long_pred[0:10])
print(y_long_real[0:10])
```

```
WARNING:tensorflow:AutoGraph could not transform <function
Model.make_predict_function.<locals>.predict_function at 0x000002E0D04A5700> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function
Model.make_predict_function.<locals>.predict_function at 0x000002E0D04A5700> and
will run it as-is.
Please report this to the TensorFlow team. When filing the bug, set the
verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`) and attach the full
output.
Cause: closure mismatch, requested ('self', 'step_function'), but source
```

```
function had ()
To silence this warning, decorate the function with
@tf.autograph.experimental.do_not_convert
[[2.1662493]
 [2.1646667]
 [2.1634624]
 [2.1653879]
 [2.1650794]
 [2.164174 ]
 [2.1648023]
 [2.1640968]
 [2.1636622]
 [2.1644373]]
[[2.16629446]
 [2.16462951]
 [2.16345464]
 [2.16541696]
 [2.16511773]
 [2.164142  ]
 [2.16484642]
 [2.1641474 ]
 [2.1636299 ]
 [2.1644339 ]]
```

2.0.7 Resultados

[606]:
```
def get_avg_distance(lat_pred,long_pred,lat_real,long_real):
    total_distance = 0
    square_error = 0
    for i in range(len(lat_pred)):
        distance = hs.haversine(( lat_pred[i][0], long_pred[i][0] ),(␣
↪lat_real[i][0], long_real[i][0] ), unit=Unit.METERS)
        total_distance += distance
        square_error += distance**2
    avg_distance = total_distance/len(lat_pred)
    std_deviation = math.sqrt(square_error)/(len(lat_pred)-1)
    return avg_distance, std_deviation
```

[607]:
```
avg_distance = get_avg_distance(y_lat_pred,y_long_pred,y_lat_real,y_long_real)
print(f"Average distance {avg_distance}")
```

```
Average distance (5.067601507336725, 0.24933699686066)
```

2.1 Predicción de siguientes posiciones

[608]:
```
columns  = ["lat_0", "long_0", "lat_1", "long_1", "lat_2", "long_2", "lat_3",␣
↪"long_3", "lat_4", "long_4",
             "lat_5", "long_5", "lat_6", "long_6", "lat_7", "long_7", "lat_8",␣
↪"long_8", "lat_9", "long_9",
            "lat_10", "long_10", "lat_11", "long_11", "lat_12", "long_12",␣
↪"lat_13", "long_13", "lat_14", "long_14"]
```

[609]:
```
df_res = pd.DataFrame(columns=columns)
```

[610]:
```
ini = 0
fin = 1000
X_mlp_test = X_mlp_test[ini:fin]
y_mlp_lat_test = y_mlp_lat_test[ini:fin]
y_mlp_long_test = y_mlp_long_test[ini:fin]
X_mlp_test_real = X_mlp_test_full[ini:fin]

# Create predictions dataframe
df_pred = X_mlp_test_real[columns]

############## FIRST ITERATION ##############
# Predicción 1
start = time.time()
y_lat_pred_1 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_1 = scaler_lat.inverse_transform(y_lat_pred_1)
y_lat_real_1 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_1 = model_mlp_long.predict(X_mlp_test)
y_long_pred_1 = scaler_long.inverse_transform(y_long_pred_1)
y_long_real_1 = scaler_long.inverse_transform(y_mlp_long_test)
end = time.time()
print(f"Time 1000 predictions: {end - start}s")

############## SECOND ITERATION ##############
# Datos para predicción 2
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_15", "long_15",␣
↪"lat_16", "long_16", "lat_17", "long_17",
                                   "lat_18", "long_18", "lat_19", "long_19",␣
↪"lat_20", "long_20", "lat_21", "long_21",
                                   "lat_22", "long_22", "lat_23", "long_23",␣
↪"lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)
```

```
y_mlp_lat_test = y_mlp_lat_test_full[["lat_16"]]
y_mlp_long_test = y_mlp_long_test_full[["long_16"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 2
y_lat_pred_2 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_2 = scaler_lat.inverse_transform(y_lat_pred_2)
y_lat_real_2 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_2 = model_mlp_long.predict(X_mlp_test)
y_long_pred_2 = scaler_long.inverse_transform(y_long_pred_2)
y_long_real_2 = scaler_long.inverse_transform(y_mlp_long_test)


############## THIRD ITERATION ##############
# Datos para predicción 3
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
 ↪"lat_15", "long_15", "lat_16", "long_16",
                                   "lat_17", "long_17", "lat_18", "long_18",␣
 ↪"lat_19", "long_19", "lat_20", "long_20",
                                   "lat_21", "long_21", "lat_22", "long_22",␣
 ↪"lat_23", "long_23", "lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_17"]]
y_mlp_long_test = y_mlp_long_test_full[["long_17"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 3
y_lat_pred_3 = model_mlp_lat.predict(X_mlp_test)
```

```
y_lat_pred_3 = scaler_lat.inverse_transform(y_lat_pred_3)
y_lat_real_3 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_3 = model_mlp_long.predict(X_mlp_test)
y_long_pred_3 = scaler_long.inverse_transform(y_long_pred_3)
y_long_real_3 = scaler_long.inverse_transform(y_mlp_long_test)


############## FOURTH ITERATION ##############
# Datos para predicción 4
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
 ↪"lat_2", "long_2", "lat_15", "long_15",
                                   "lat_16", "long_16", "lat_17", "long_17",␣
 ↪"lat_18", "long_18", "lat_19", "long_19",
                                   "lat_20", "long_20", "lat_21", "long_21",␣
 ↪"lat_22", "long_22", "lat_23", "long_23", "lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
X_mlp_test["lat_17"] = y_lat_pred_3
X_mlp_test["long_17"] = y_long_pred_3
X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_18"]]
y_mlp_long_test = y_mlp_long_test_full[["long_18"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 4
y_lat_pred_4 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_4 = scaler_lat.inverse_transform(y_lat_pred_4)
y_lat_real_4 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_4 = model_mlp_long.predict(X_mlp_test)
y_long_pred_4 = scaler_long.inverse_transform(y_long_pred_4)
y_long_real_4 = scaler_long.inverse_transform(y_mlp_long_test)

############## FIFTH ITERATION ##############
# Datos para predicción 5
```

```
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
↪"lat_2", "long_2", "lat_3", "long_3", "lat_15",
                                   "long_15", "lat_16", "long_16", "lat_17",␣
↪"long_17", "lat_18", "long_18", "lat_19", "long_19",
                                   "lat_20", "long_20", "lat_21", "long_21",␣
↪"lat_22", "long_22", "lat_23", "long_23", "lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
X_mlp_test["lat_17"] = y_lat_pred_3
X_mlp_test["long_17"] = y_long_pred_3
X_mlp_test["lat_18"] = y_lat_pred_4
X_mlp_test["long_18"] = y_long_pred_4
X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_19"]]
y_mlp_long_test = y_mlp_long_test_full[["long_19"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 5
y_lat_pred_5 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_5 = scaler_lat.inverse_transform(y_lat_pred_5)
y_lat_real_5 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_5 = model_mlp_long.predict(X_mlp_test)
y_long_pred_5 = scaler_long.inverse_transform(y_long_pred_5)
y_long_real_5 = scaler_long.inverse_transform(y_mlp_long_test)

############## SIXTH ITERATION ##############
# Datos para predicción 6
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
↪"lat_2", "long_2", "lat_3", "long_3", "lat_4", "long_4",
                                   "lat_15", "long_15", "lat_16", "long_16",␣
↪"lat_17", "long_17", "lat_18", "long_18", "lat_19",
                                   "long_19", "lat_20", "long_20", "lat_21",␣
↪"long_21", "lat_22", "long_22", "lat_23",
                                   "long_23", "lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
```

```
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
X_mlp_test["lat_17"] = y_lat_pred_3
X_mlp_test["long_17"] = y_long_pred_3
X_mlp_test["lat_18"] = y_lat_pred_4
X_mlp_test["long_18"] = y_long_pred_4
X_mlp_test["lat_19"] = y_lat_pred_5
X_mlp_test["long_19"] = y_long_pred_5

X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_20"]]
y_mlp_long_test = y_mlp_long_test_full[["long_20"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 6
y_lat_pred_6 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_6 = scaler_lat.inverse_transform(y_lat_pred_6)
y_lat_real_6 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_6 = model_mlp_long.predict(X_mlp_test)
y_long_pred_6 = scaler_long.inverse_transform(y_long_pred_6)
y_long_real_6 = scaler_long.inverse_transform(y_mlp_long_test)

############## SEVENTH ITERATION ##############
# Datos para predicción 7
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
 ↪"lat_2", "long_2", "lat_3", "long_3", "lat_4",
                                   "long_4", "lat_5", "long_5",
                                   "lat_15", "long_15", "lat_16", "long_16",␣
 ↪"lat_17", "long_17", "lat_18", "long_18", "lat_19",
                                   "long_19", "lat_20", "long_20", "lat_21",␣
 ↪"long_21", "lat_22", "long_22", "lat_23",
                                   "long_23", "lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
X_mlp_test["lat_17"] = y_lat_pred_3
```

```
X_mlp_test["long_17"] = y_long_pred_3
X_mlp_test["lat_18"] = y_lat_pred_4
X_mlp_test["long_18"] = y_long_pred_4
X_mlp_test["lat_19"] = y_lat_pred_5
X_mlp_test["long_19"] = y_long_pred_5
X_mlp_test["lat_20"] = y_lat_pred_6
X_mlp_test["long_20"] = y_long_pred_6

X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_21"]]
y_mlp_long_test = y_mlp_long_test_full[["long_21"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 7
y_lat_pred_7 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_7 = scaler_lat.inverse_transform(y_lat_pred_7)
y_lat_real_7 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_7 = model_mlp_long.predict(X_mlp_test)
y_long_pred_7 = scaler_long.inverse_transform(y_long_pred_7)
y_long_real_7 = scaler_long.inverse_transform(y_mlp_long_test)

############## EIGHTH ITERATION ##############
# Datos para predicción 8
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
↪"lat_2", "long_2", "lat_3", "long_3", "lat_4",
                                   "long_4", "lat_5", "long_5", "lat_6",␣
↪"long_6",
                                   "lat_15", "long_15", "lat_16", "long_16",␣
↪"lat_17", "long_17", "lat_18", "long_18", "lat_19",
                                   "long_19", "lat_20", "long_20", "lat_21",␣
↪"long_21", "lat_22", "long_22", "lat_23",
                                   "long_23", "lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
X_mlp_test["lat_17"] = y_lat_pred_3
X_mlp_test["long_17"] = y_long_pred_3
```

```python
X_mlp_test["lat_18"] = y_lat_pred_4
X_mlp_test["long_18"] = y_long_pred_4
X_mlp_test["lat_19"] = y_lat_pred_5
X_mlp_test["long_19"] = y_long_pred_5
X_mlp_test["lat_20"] = y_lat_pred_6
X_mlp_test["long_20"] = y_long_pred_6
X_mlp_test["lat_21"] = y_lat_pred_7
X_mlp_test["long_21"] = y_long_pred_7


X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_22"]]
y_mlp_long_test = y_mlp_long_test_full[["long_22"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 8
y_lat_pred_8 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_8 = scaler_lat.inverse_transform(y_lat_pred_8)
y_lat_real_8 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_8 = model_mlp_long.predict(X_mlp_test)
y_long_pred_8 = scaler_long.inverse_transform(y_long_pred_8)
y_long_real_8 = scaler_long.inverse_transform(y_mlp_long_test)

############## NINTH ITERATION ##############
# Datos para predicción 9
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
 ↪"lat_2", "long_2", "lat_3", "long_3", "lat_4",
                                   "long_4", "lat_5", "long_5", "lat_6",␣
 ↪"long_6", "lat_7", "long_7",
                                   "lat_15", "long_15", "lat_16", "long_16",␣
 ↪"lat_17", "long_17", "lat_18", "long_18", "lat_19",
                                   "long_19", "lat_20", "long_20", "lat_21",␣
 ↪"long_21", "lat_22", "long_22", "lat_23",
                                   "long_23", "lat_24", "long_24"], axis=1)
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
```

```python
X_mlp_test["lat_17"] = y_lat_pred_3
X_mlp_test["long_17"] = y_long_pred_3
X_mlp_test["lat_18"] = y_lat_pred_4
X_mlp_test["long_18"] = y_long_pred_4
X_mlp_test["lat_19"] = y_lat_pred_5
X_mlp_test["long_19"] = y_long_pred_5
X_mlp_test["lat_20"] = y_lat_pred_6
X_mlp_test["long_20"] = y_long_pred_6
X_mlp_test["lat_21"] = y_lat_pred_7
X_mlp_test["long_21"] = y_long_pred_7
X_mlp_test["lat_22"] = y_lat_pred_8
X_mlp_test["long_22"] = y_long_pred_8


X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_23"]]
y_mlp_long_test = y_mlp_long_test_full[["long_23"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 9
y_lat_pred_9 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_9 = scaler_lat.inverse_transform(y_lat_pred_9)
y_lat_real_9 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_9 = model_mlp_long.predict(X_mlp_test)
y_long_pred_9  = scaler_long.inverse_transform(y_long_pred_9)
y_long_real_9 = scaler_long.inverse_transform(y_mlp_long_test)

############## TENTH ITERATION ##############
# Datos para predicción 10
X_mlp_test = X_mlp_test_real.drop(["lat_0", "long_0", "lat_1", "long_1",␣
 ↪"lat_2", "long_2", "lat_3", "long_3", "lat_4",
                                   "long_4", "lat_5", "long_5", "lat_6",␣
 ↪"long_6", "lat_7", "long_7", "lat_8", "long_8",
                                   "lat_15", "long_15", "lat_16", "long_16",␣
 ↪"lat_17", "long_17", "lat_18", "long_18", "lat_19",
                                   "long_19", "lat_20", "long_20", "lat_21",␣
 ↪"long_21", "lat_22", "long_22", "lat_23",
                                   "long_23", "lat_24", "long_24"], axis=1)
```

```
X_mlp_test["lat_15"] = y_lat_pred_1
X_mlp_test["long_15"] = y_long_pred_1
X_mlp_test["lat_16"] = y_lat_pred_2
X_mlp_test["long_16"] = y_long_pred_2
X_mlp_test["lat_17"] = y_lat_pred_3
X_mlp_test["long_17"] = y_long_pred_3
X_mlp_test["lat_18"] = y_lat_pred_4
X_mlp_test["long_18"] = y_long_pred_4
X_mlp_test["lat_19"] = y_lat_pred_5
X_mlp_test["long_19"] = y_long_pred_5
X_mlp_test["lat_20"] = y_lat_pred_6
X_mlp_test["long_20"] = y_long_pred_6
X_mlp_test["lat_21"] = y_lat_pred_7
X_mlp_test["long_21"] = y_long_pred_7
X_mlp_test["lat_22"] = y_lat_pred_8
X_mlp_test["long_22"] = y_long_pred_8
X_mlp_test["lat_23"] = y_lat_pred_9
X_mlp_test["long_23"] = y_long_pred_9

print(X_mlp_test)
print(len(columns))

X_mlp_test.columns = columns
scaler = StandardScaler().fit(X_mlp_test)
X_mlp_test = scaler.transform(X_mlp_test)

y_mlp_lat_test = y_mlp_lat_test_full[["lat_24"]]
y_mlp_long_test = y_mlp_long_test_full[["long_24"]]
y_mlp_lat_test.columns = ["lat_15"]
y_mlp_long_test.columns = ["long_15"]
scaler_lat = StandardScaler().fit(y_mlp_lat_test)
scaler_long = StandardScaler().fit(y_mlp_long_test)
y_mlp_lat_test = scaler_lat.transform(y_mlp_lat_test)
y_mlp_long_test = scaler_long.transform(y_mlp_long_test)

# Predicción 10
y_lat_pred_10 = model_mlp_lat.predict(X_mlp_test)
y_lat_pred_10 = scaler_lat.inverse_transform(y_lat_pred_10)
y_lat_real_10 = scaler_lat.inverse_transform(y_mlp_lat_test)

y_long_pred_10 = model_mlp_long.predict(X_mlp_test)
y_long_pred_10 = scaler_long.inverse_transform(y_long_pred_10)
y_long_real_10 = scaler_long.inverse_transform(y_mlp_long_test)



############## Create results dataframe ##############
```

```
df_pred = df_pred.assign(lat_15=y_lat_pred_1, long_15=y_long_pred_1,␣
 ↪lat_16=y_lat_pred_2, long_16=y_long_pred_2,
                        lat_17=y_lat_pred_3, long_17=y_long_pred_3,␣
 ↪lat_18=y_lat_pred_4, long_18=y_long_pred_4,
                        lat_19=y_lat_pred_5, long_19=y_long_pred_5,␣
 ↪lat_20=y_lat_pred_6, long_20=y_long_pred_6,
                        lat_21=y_lat_pred_7, long_21=y_long_pred_7,␣
 ↪lat_22=y_lat_pred_8, long_22=y_long_pred_8,
                        lat_23=y_lat_pred_9, long_23=y_long_pred_9,␣
 ↪lat_24=y_lat_pred_9, long_24=y_long_pred_9,
                        lat_25=y_lat_pred_10, long_25=y_long_pred_10)
```

```
Time 1000 predictions: 0.26798510551452637s
            lat_9    long_9     lat_10   long_10     lat_11   long_11  \
21503   41.391283  2.166294  41.391283  2.166294  41.391283  2.166294
10056   41.390261  2.164762  41.390261  2.164762  41.390264  2.164758
140155  41.393327  2.163455  41.393327  2.163455  41.393327  2.163455
29624   41.389761  2.165417  41.389761  2.165417  41.389761  2.165417
131647  41.392062  2.165118  41.392062  2.165118  41.392062  2.165118
…             …         …          …         …          …         …
110825  41.391315  2.165713  41.391315  2.165713  41.391315  2.165713
5240    41.390291  2.164367  41.390291  2.164367  41.390291  2.164367
7994    41.393144  2.163438  41.393139  2.163443  41.393132  2.163453
47474   41.391030  2.165618  41.391030  2.165618  41.391040  2.165631
94150   41.391654  2.165613  41.391654  2.165613  41.391654  2.165613

           lat_12   long_12     lat_13   long_13  …     lat_19   long_19  \
21503   41.391283  2.166294  41.391283  2.166294  …  41.391342  2.166167
10056   41.390276  2.164742  41.390294  2.164716  …  41.390530  2.164614
140155  41.393327  2.163455  41.393327  2.163455  …  41.393410  2.163493
29624   41.389761  2.165417  41.389761  2.165417  …  41.389915  2.165330
131647  41.392062  2.165118  41.392062  2.165118  …  41.392082  2.164984
…             …         …          …         …  …        …         …
110825  41.391315  2.165713  41.391315  2.165713  …  41.391319  2.165632
5240    41.390291  2.164367  41.390291  2.164367  …  41.390434  2.164494
7994    41.393118  2.163470  41.393113  2.163476  …  41.393208  2.163543
47474   41.391055  2.165652  41.391093  2.165702  …  41.391350  2.165743
94150   41.391654  2.165613  41.391654  2.165613  …  41.391693  2.165528

           lat_20   long_20     lat_21   long_21     lat_22   long_22  \
21503   41.391335  2.166176  41.391327  2.166187  41.391319  2.166199
10056   41.390560  2.164604  41.390587  2.164599  41.390617  2.164588
140155  41.393425  2.163474  41.393440  2.163453  41.393459  2.163434
29624   41.389919  2.165326  41.389923  2.165324  41.389931  2.165320
131647  41.392071  2.164953  41.392059  2.164917  41.392048  2.164875
…             …         …          …         …          …         …
```

```
110825  41.391300  2.165642  41.391281  2.165652  41.391262  2.165663
5240    41.390442  2.164523  41.390446  2.164555  41.390457  2.164585
7994    41.393234  2.163527  41.393257  2.163507  41.393284  2.163489
47474   41.391373  2.165766  41.391396  2.165790  41.391418  2.165813
94150   41.391682  2.165534  41.391666  2.165540  41.391647  2.165547

           lat_23   long_23
21503   41.391312  2.166209
10056   41.390652  2.164580
140155  41.393475  2.163413
29624   41.389938  2.165315
131647  41.392036  2.164831
…             …         …
110825  41.391243  2.165676
5240    41.390465  2.164616
7994    41.393311  2.163473
47474   41.391441  2.165847
94150   41.391624  2.165554

[1000 rows x 30 columns]
30
```

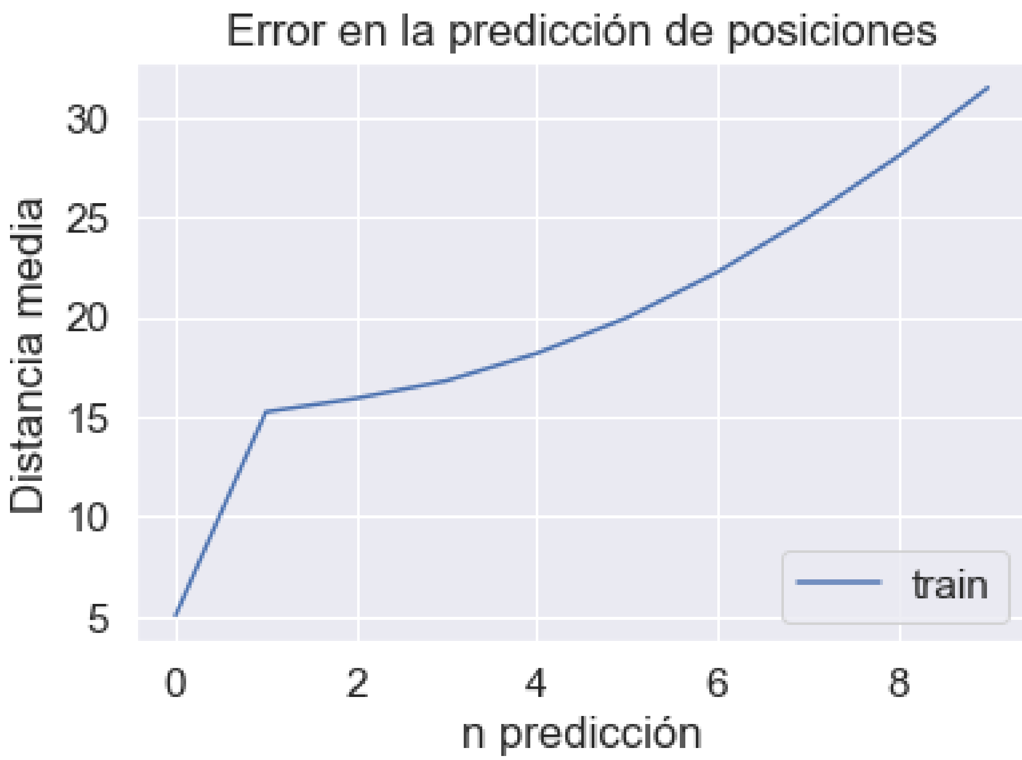
[611]:
```
len(X_mlp_test[0])
```

[611]: 30

[612]:
```
avg_distances = []
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_1,y_long_pred_1,y_lat_real_1,y_long_real_1)
avg_distances.append(avg_distance)
print(f"Average distance 1: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_2,y_long_pred_2,y_lat_real_2,y_long_real_2)
avg_distances.append(avg_distance)
print(f"Average distance 2: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_3,y_long_pred_3,y_lat_real_3,y_long_real_3)
avg_distances.append(avg_distance)
print(f"Average distance 3: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_4,y_long_pred_4,y_lat_real_4,y_long_real_4)
avg_distances.append(avg_distance)
print(f"Average distance 4: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_5,y_long_pred_5,y_lat_real_5,y_long_real_5)
avg_distances.append(avg_distance)
print(f"Average distance 5: {avg_distance}")
```

```python
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_6,y_long_pred_6,y_lat_real_6,y_long_real_6)
avg_distances.append(avg_distance)
print(f"Average distance 6: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_7,y_long_pred_7,y_lat_real_7,y_long_real_7)
avg_distances.append(avg_distance)
print(f"Average distance 7: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_8,y_long_pred_8,y_lat_real_8,y_long_real_8)
avg_distances.append(avg_distance)
print(f"Average distance 8: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_9,y_long_pred_9,y_lat_real_9,y_long_real_9)
avg_distances.append(avg_distance)
print(f"Average distance 9: {avg_distance}")
avg_distance, std_deviation =␣
 ↪get_avg_distance(y_lat_pred_10,y_long_pred_10,y_lat_real_10,y_long_real_10)
avg_distances.append(avg_distance)
print(f"Average distance 10: {avg_distance}")
plot_distance_errors(avg_distances)
```

```
Average distance 1: 5.067601507336725
Average distance 2: 15.25185498477966
Average distance 3: 15.926260271347303
Average distance 4: 16.80802075214277
Average distance 5: 18.175948149957375
Average distance 6: 19.963563576409662
Average distance 7: 22.234883446054578
Average distance 8: 24.96743614393459
Average distance 9: 28.016318248081156
Average distance 10: 31.467334734957703
```



3 Colisiones

3.1 Funciones

3.1.1 Zona de colisión

[613]:
```
def get_rectangle_bounds(coordinates, width, length):
    start = geopy.Point(coordinates)
    hypotenuse = math.hypot(width/1000, length/1000)

    # Edit used wrong formula to convert radians to degrees, use math builtin␣
 ↪function
    northeast_angle = 0 - math.degrees(math.atan(width/length))
    southwest_angle = 180 - math.degrees(math.atan(width/length))

    d = geopy.distance.distance(kilometers=hypotenuse/2)
    northeast = d.destination(point=start, bearing=northeast_angle)
    southwest = d.destination(point=start, bearing=southwest_angle)
    bounds = []
    for point in [northeast, southwest]:
        coords = (point.latitude, point.longitude)
        bounds.append(coords)
```

```
    return bounds
```

3.1.2 Bearing

[614]:
```
def bear(coords1, coords2):
    lat1 = coords1[0]
    lon1 = coords1[1]
    lat2 = coords2[0]
    lon2 = coords2[1]

    rlat1 = math.radians(lat1)
    rlon1 = math.radians(lon1)
    rlat2 = math.radians(lat2)
    rlon2 = math.radians(lon2)
    dlon = math.radians(lon2-lon1)
    b = math.atan2(math.sin(dlon)*math.cos(rlat2),math.cos(rlat1)*math.
 ↪sin(rlat2)-math.sin(rlat1)*math.cos(rlat2)*math.cos(dlon))
    bd = math.degrees(b)
    br,bn = divmod(bd+360,360) # the bearing remainder and final bearing
    return bn
```

3.1.3 Rotating points

[615]:
```
# To get a rotated rectangle at a bearing, you need to get the points of the␣
 ↪the recatangle at that bearing
def get_rotated_points(coordinates, bearing, width, length):
    start = geopy.Point(coordinates)
    width  = width/1000
    length = length/1000
    rectlength = geopy.distance.distance(kilometers=length)
    rectwidth = geopy.distance.distance(kilometers=width)
    halfwidth = geopy.distance.distance(kilometers=width/2)
    halflength = geopy.distance.distance(kilometers=length/2)

    pointAB = halflength.destination(point=start, bearing=bearing)
    pointA = halfwidth.destination(point=pointAB, bearing=0-bearing)
    pointB = rectwidth.destination(point=pointA, bearing=180-bearing)
    pointC = rectlength.destination(point=pointB, bearing=bearing-180)
    pointD = rectwidth.destination(point=pointC, bearing=0-bearing)

    points = []
    for point in [pointA, pointB, pointC, pointD]:
        coords = (point.latitude, point.longitude)
        points.append(coords)

    return points
```

3.1.4 Colisión

[616]:
```
def get_colision_risk(distances, avg_distances=avg_distances):
    min_distance = min(distances)
    time = distances.index(min_distance)
    mean_error = 2*avg_distances[time]
    dif = min_distance-mean_error
    if dif >= 0:
        return 0, time
    risk = max(abs(dif), 0)/mean_error
    return risk, time
```

[617]:
```
def is_colision(vehicle1, vehicle2, init_pred=15, total_preds=5, length = 4,␣
 ↪width = 1.50, avg_distances=avg_distances):
    distances = []
    for i in range(init_pred,init_pred+total_preds):
        lat1 = vehicle1["lat_"+str(i)]
        lon1 = vehicle1["long_"+str(i)]
        lat2 = vehicle2["lat_"+str(i)]
        lon2 = vehicle2["long_"+str(i)]

        lat1_prev = vehicle1["lat_"+str(i-1)]
        lon1_prev = vehicle1["long_"+str(i-1)]
        lat2_prev = vehicle2["lat_"+str(i-1)]
        lon2_prev = vehicle2["long_"+str(i-1)]

        start_coords1 = [lat1_prev, lon1_prev]
        start_coords2 = [lat2_prev, lon2_prev]

        next_coords1 = [lat1, lon1]
        next_coords2 = [lat2, lon2]

        bearing1 = bear(start_coords1, next_coords1)
        bearing2 = bear(start_coords2, next_coords2)

        #bounds1 = get_rectangle_bounds(tuple(start_coords1),width, length)
        #bounds2 = get_rectangle_bounds(tuple(start_coords2),width, length)

        points1 = get_rotated_points(tuple(start_coords1), bearing1, width,␣
 ↪length)
        points2 = get_rotated_points(tuple(start_coords2), bearing2, width,␣
 ↪length)

        polygon1 = geometry.Polygon(points1)
        polygon2 = geometry.Polygon(points2)

        if i==init_pred:
```

```python
            map = folium.Map([(start_coords1[0]+start_coords2[0])/2,␣
↪(start_coords1[1]+start_coords2[1])/2], zoom_start=20)
        folium.Polygon(points1, color='red').add_to(map)
        folium.Polygon(points2, color='green').add_to(map)

        if (polygon1.intersection(polygon2).area > 0.0):
            return True, map, 1, i-init_pred

        else:
            distances.append(hs.haversine(( next_coords1 ),( next_coords2 ),␣
↪unit=Unit.METERS))

    collision_risk, time = get_colision_risk(distances,␣
↪avg_distances=avg_distances)
    return False, map, collision_risk, time
```

[618]:

```python
# Probabilidades de colisión del vehículo 80 con los otros vehículos
for i in range(100):
    vehicle1 = df_pred.iloc[80]
    vehicle2 = df_pred.iloc[i]
    colision, map, collision_risk, time = is_colision(vehicle1, vehicle2)
    print(i, collision_risk)
```

```
0 0
1 0.32214338618534627
2 0
3 0
4 0
5 0
6 0
7 0
8 0
9 0
10 0
11 0
12 0
13 0
14 0
15 0
16 0
17 0
18 0
19 0
20 0
21 0
22 0
23 0
```

24 0
25 0
26 0
27 0
28 0
29 0
30 0
31 0
32 0
33 0
34 0
35 0
36 0
37 0
38 0
39 0
40 0
41 0
42 0
43 0
44 0
45 0
46 0
47 0
48 0
49 0
50 0
51 0
52 0
53 0
54 0
55 0
56 0
57 0
58 0
59 0
60 0
61 0
62 0
63 0
64 0
65 0
66 0
67 0
68 0
69 0
70 0
71 0

```
72 0
73 0
74 0
75 0
76 0
77 0
78 0
79 0
80 1
81 0
82 0
83 0
84 0
85 0
86 0
87 0
88 0
89 0
90 0
91 0
92 0
93 0
94 0
95 0
96 0
97 0
98 0
99 0
```

[619]:
```
vehicle1 = X_mlp_test_full.iloc[80]
vehicle2 = X_mlp_test_full.iloc[11]
colision, map, collision_risk, time = is_colision(vehicle1, vehicle2)
print(colision, collision_risk, time)
```

```
False 0 4
```

[620]:
```
map
```

[620]:
```
<folium.folium.Map at 0x2e0c267b0a0>
```

[621]:
```
vehicle1 = df_pred.iloc[80]
vehicle2 = df_pred.iloc[11]
colision, map, collision_risk, time = is_colision(vehicle1, vehicle2)
print(colision, collision_risk, time)
```

```
False 0 4
```

[622]:
```
map
```

[622]: <folium.folium.Map at 0x2e0c0384d30>

4 Predicción de colisiones

4.0.1 Preparación de datos

[260]:
```
def format_dataset_collisions(df, initial_time, n):

    final_time = initial_time+n

    df = df[(df["time"]>=initial_time) & (df["time"]<final_time)]

    df = df.sort_values(['vehicle_id', 'time'])
    df = df.reset_index(drop=True)

    data = []
    temp_data = []
    temp_i = 0
    temp_vehicle = df.loc[0, 'vehicle_id']

    for i in range(1, df.shape[0]):
        row = df.loc[i]

        if row["vehicle_id"] != temp_vehicle:
            temp_vehicle = row["vehicle_id"]
            temp_i = 0
            temp_data = []
            temp_data.append(row["vehicle_id"])
            temp_data.append(row["latitude"])
            temp_data.append(row["longitude"])
            temp_data.append(row["collision"])
            temp_data.append(row["victim_id"])

        elif temp_i < n-1:
            temp_data.append(row["latitude"])
            temp_data.append(row["longitude"])
            temp_data.append(row["collision"])
            temp_data.append(row["victim_id"])

        else:
            temp_data.append(row["latitude"])
            temp_data.append(row["longitude"])
            temp_data.append(row["collision"])
            temp_data.append(row["victim_id"])
            data.append(temp_data)
            temp_data = []
            temp_i = 0
```

```
            temp_vehicle = -1
        temp_i += 1


    return data

#mlp_data = format_dataset_collisions(df, 0, 25)
```

[261]:
```
columns  = ["vehicle_id", "lat_0", "long_0", "collision_0",  "victim_id_0",
            "lat_1", "long_1", "collision_1", "victim_id_1", "lat_2", "long_2",␣
 ↪"collision_2", "victim_id_2",
             "lat_3", "long_3", "collision_3",  "victim_id_3", "lat_4",␣
 ↪"long_4", "collision_4",  "victim_id_4",
             "lat_5", "long_5", "collision_5",  "victim_id_5", "lat_6",␣
 ↪"long_6", "collision_6",  "victim_id_6",
            "lat_7", "long_7", "collision_7",  "victim_id_7", "lat_8",␣
 ↪"long_8", "collision_8",  "victim_id_8",
            "lat_9", "long_9", "collision_9",  "victim_id_9", "lat_10",␣
 ↪"long_10", "collision_10",  "victim_id_10",
            "lat_11", "long_11", "collision_11",  "victim_id_11", "lat_12",␣
 ↪"long_12", "collision_12",  "victim_id_12",
            "lat_13", "long_13", "collision_13",  "victim_id_13", "lat_14",␣
 ↪"long_14", "collision_14",  "victim_id_14",
            "lat_15", "long_15", "collision_15",  "victim_id_15", "lat_16",␣
 ↪"long_16", "collision_16",  "victim_id_16",
            "lat_17", "long_17", "collision_17",  "victim_id_17", "lat_18",␣
 ↪"long_18", "collision_18",  "victim_id_18",
            "lat_19", "long_19", "collision_19",  "victim_id_19", "lat_20",␣
 ↪"long_20", "collision_20",  "victim_id_20",
            "lat_21", "long_21", "collision_21",  "victim_id_21", "lat_22",␣
 ↪"long_22", "collision_22",  "victim_id_22",
            "lat_23", "long_23", "collision_23",  "victim_id_23", "lat_24",␣
 ↪"long_24", "collision_24",  "victim_id_24"]

for i in range(8, 10008, 25):
    col_data = format_dataset_collisions(df, i, 25)
    df_col = pd.DataFrame(col_data, columns=columns )
    df_col.to_csv(f"collision_dfs/df_collisions_{i}_{i+25}.csv")
```

[262]:
```
#pd.read_csv("collision_dfs/df_collisions_100_125.csv")
```

[263]:
```
df_names = []
df_full_names = []
for i in range(8, 10008, 25):
    df_names.append(f"collision_dfs/df_collisions_{i}_{i+25}.csv"[14:-4])
    df_full_names.append(f"collision_dfs/df_collisions_{i}_{i+25}.csv")
```

```
collision_dfs = {}
for i in range(len(df_names)):
    collision_dfs[df_names[i]] = pd.read_csv(df_full_names[i]).drop(["Unnamed:␣
 ↪0"], axis=1)
```

[264]:
```
pred_columns  = ["lat_0", "long_0", "lat_1", "long_1", "lat_2", "long_2",␣
 ↪"lat_3", "long_3", "lat_4", "long_4",
             "lat_5", "long_5", "lat_6", "long_6", "lat_7", "long_7", "lat_8",␣
 ↪"long_8", "lat_9", "long_9",
            "lat_10", "long_10", "lat_11", "long_11", "lat_12", "long_12",␣
 ↪"lat_13", "long_13", "lat_14", "long_14",
            "lat_15", "long_15", "lat_16", "long_16", "lat_17", "long_17",␣
 ↪"lat_18", "long_18", "lat_19", "long_19",
            "lat_20", "long_20", "lat_21", "long_21", "lat_22", "long_22",␣
 ↪"lat_23", "long_23", "lat_24", "long_24"]

real_columns  = ["lat_0", "long_0", "lat_1", "long_1", "lat_2", "long_2",␣
 ↪"lat_3", "long_3", "lat_4", "long_4",
             "lat_5", "long_5", "lat_6", "long_6", "lat_7", "long_7", "lat_8",␣
 ↪"long_8", "lat_9", "long_9",
            "lat_10", "long_10", "lat_11", "long_11", "lat_12", "long_12",␣
 ↪"lat_13", "long_13", "lat_14", "long_14"]
```

[265]:
```
dfs_with_collisions = []
for key in collision_dfs.keys():
    df_col = collision_dfs[key]
    for i in range(15,25):
        hay_colision = len(df_col[df_col['collision_'+str(i)]==1])
        if(hay_colision)>0:
            dfs_with_collisions.append(key)
            print(key)
```

```
df_collisions_1033_1058
df_collisions_1508_1533
df_collisions_2233_2258
df_collisions_2558_2583
df_collisions_3433_3458
df_collisions_4133_4158
df_collisions_4333_4358
df_collisions_4833_4858
df_collisions_5058_5083
df_collisions_5133_5158
df_collisions_5158_5183
df_collisions_5408_5433
df_collisions_6258_6283
df_collisions_6758_6783
```

```
df_collisions_7583_7608
df_collisions_8183_8208
df_collisions_8783_8808
df_collisions_9258_9283
df_collisions_9858_9883
df_collisions_9908_9933
```

[266]:
```python
df_colls = {k: collision_dfs[k] for k in dfs_with_collisions}
df_colls_pos = {k: collision_dfs[k][pred_columns] for k in dfs_with_collisions}
```

4.0.2 Transformar para regresión

[297]:
```python
def format_dataset_regresion_collisions(df, n):

    data = []
    temp_data = []

    for i in range(0, df.shape[0]):
        row = df.loc[i]
        temp_data = []
        for i in range(n):
            temp_data.append([row['lat_'+str(i)], row['long_'+str(i)]])
        data.append(temp_data)
    data = np.array(data, dtype='float64')
    return data

for key in df_colls_pos.keys():
    data_colls = format_dataset_regresion_collisions(df_colls[key], 25)
    np.save(file=f"reg_coll_data/{key}.npy", arr=data_colls)
```

[300]:
```python
data_colls ={}
for key in df_colls_pos.keys():
    data_colls[key] = np.load(f"reg_coll_data/{key}.npy")
```

4.0.3 Predecir trayectorias

[301]:
```python
def call_get_next_10_positions_res(dataset, model):
    df_colls_res = pd.DataFrame(columns=pred_columns)
    array_colls_res = np.empty((0,50))
    array_colls_res = []
    for data in dataset:
        prediction = get_next_10_positions(data, model)
        array_colls_res.append(prediction)
    df_colls_res = pd.DataFrame(array_colls_res, columns=pred_columns)
    return df_colls_res
```

[302]:
```
def get_next_10_positions(data, model):

    df_res = data[0:15]

    # Prediction 1
    X = data[0:15]
    y = data[1:16]
    model.fit(X, y)
    pred_1 = model.predict([y[-1]])
    real_1 = data[16]

    # Prediction 2
    X = np.concatenate((data[1:15], pred_1))
    y = np.concatenate((data[2:15], pred_1, [real_1]))
    model.fit(X, y)
    pred_2 = model.predict([y[-1]])
    real_2 = data[17]

    # Prediction 3
    X = np.concatenate((data[2:15], pred_1, pred_2))
    y = np.concatenate((data[3:15], pred_1, pred_2, [real_2]))
    model.fit(X, y)
    pred_3 = model.predict([y[-1]])
    real_3 = data[18]

    # Prediction 4
    X = np.concatenate((data[3:15], pred_1, pred_2, pred_3))
    y = np.concatenate((data[4:15], pred_1, pred_2, pred_3, [real_3]))
    model.fit(X, y)
    pred_4 = model.predict([y[-1]])
    real_4 = data[19]

    # Prediction 5
    X = np.concatenate((data[4:15], pred_1, pred_2, pred_3, pred_4))
    y = np.concatenate((data[5:15], pred_1, pred_2, pred_3, pred_4, [real_4]))
    model.fit(X, y)
    pred_5 = model.predict([y[-1]])
    real_5 = data[20]

    # Prediction 6
    X = np.concatenate((data[5:15], pred_1, pred_2, pred_3, pred_4, pred_5))
    y = np.concatenate((data[6:15], pred_1, pred_2, pred_3, pred_4, pred_5,␣
 ↪[real_5]))
    model.fit(X, y)
    pred_6 = model.predict([y[-1]])
    real_6 = data[21]
```

```python
    # Prediction 7
    X = np.concatenate((data[6:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6))
    y = np.concatenate((data[7:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, [real_6]))
    model.fit(X, y)
    pred_7 = model.predict([y[-1]])
    real_7 = data[22]

    # Prediction 8
    X = np.concatenate((data[7:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7))
    y = np.concatenate((data[8:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, [real_7]))
    model.fit(X, y)
    pred_8 = model.predict([y[-1]])
    real_8 = data[23]

    # Prediction 9
    X = np.concatenate((data[8:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, pred_8))
    y = np.concatenate((data[9:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, pred_8, [real_8]))
    model.fit(X, y)
    pred_9 = model.predict([y[-1]])
    real_9 = data[24]

    # Prediction 10
    X = np.concatenate((data[9:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, pred_8, pred_9))
    y = np.concatenate((data[10:15], pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, pred_8, pred_9, [real_9]))
    model.fit(X, y)
    pred_10 = model.predict([y[-1]])
    real_10 = pred_10

    #predictions = [l.tolist() for l in [pred_1[0],pred_2[0],pred_3[0],pred_4[0],pred_5[0],pred_6[0],pred_7[0],pred_8[0],pred_9[0],
    #real_values = [l.tolist() for l in [real_1,real_2,real_3,real_4,real_5,real_6,real_7,real_8,real_9,real_10]]

    df_res = np.append(df_res, [pred_1, pred_2, pred_3, pred_4, pred_5, pred_6, pred_7, pred_8, pred_9, pred_10])

    return df_res
```

[442]:
```
'''from sklearn.tree import ExtraTreeRegressor
df_predictions ={}
for key in data_colls.keys():
    model = ExtraTreeRegressor()
    df_predictions[key] = call_get_next_10_positions_res(data_colls[key],␣
 ↪model)'''
```

[425]:
```
'''from sklearn.gaussian_process import GaussianProcessRegressor
df_predictions ={}
for key in data_colls.keys():
    model = GaussianProcessRegressor()
    df_predictions[key] = call_get_next_10_positions_res(data_colls[key],␣
 ↪model)'''
```

4.0.4 Lista de colisiones

[443]:
```
real_collisions_df = pd.DataFrame(columns=columns + ['df_time'])
for key in df_colls.keys():
    curr_df = df_colls[key]
    for i in range(15, 25):
        real_collisions = curr_df[curr_df['collision_'+str(i)]==1]
        real_collisions['df_time'] = key
        real_collisions_df = pd.concat([real_collisions_df, real_collisions])
```

```
C:\Users\DANIE\AppData\Local\Temp\ipykernel_7940\3475772495.py:6:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  real_collisions['df_time'] = key
C:\Users\DANIE\AppData\Local\Temp\ipykernel_7940\3475772495.py:6:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
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  real_collisions['df_time'] = key
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```

```
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```
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See the caveats in the documentation: https://pandas.pydata.org/pandas-
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  real_collisions['df_time'] = key
```

```
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A value is trying to be set on a copy of a slice from a DataFrame.
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Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  real_collisions['df_time'] = key
```

[444]:
```
real_collisions_df
```

[444]:
```
     vehicle_id       lat_0    long_0 collision_0 victim_id_0      lat_1  \
83       1053.0  41.391101  2.165712         0.0        -1.0  41.391101
170      1537.0  41.391258  2.163362         0.0        -1.0  41.391306
167      2159.0  41.388898  2.162727         0.0        -1.0  41.388941
```

101	2322.0	41.391561	2.164133	0.0	-1.0	41.391561
51	2927.0	41.392079	2.165081	0.0	-1.0	41.392108
180	3825.0	41.390532	2.164952	0.0	-1.0	41.390551
162	3977.0	41.393194	2.163621	0.0	-1.0	41.393194
27	3985.0	41.391911	2.1654	0.0	-1.0	41.391955
170	4659.0	41.393364	2.163408	0.0	-1.0	41.393364
106	4600.0	41.391832	2.165496	0.0	-1.0	41.391832
147	4699.0	41.390261	2.164762	0.0	-1.0	41.390261
163	4943.0	41.393078	2.166203	0.0	-1.0	41.393031
166	5562.0	41.389343	2.162701	0.0	-1.0	41.389272
156	5856.0	41.393017	2.163595	0.0	-1.0	41.393017
156	6502.0	41.391673	2.161901	0.0	-1.0	41.391716
102	6956.0	41.39103	2.16368	0.0	-1.0	41.391057
171	7462.0	41.388772	2.162561	0.0	-1.0	41.388823
60	7671.0	41.391587	2.165538	0.0	-1.0	41.391587
53	8150.0	41.391145	2.166466	0.0	-1.0	41.391162
30	7951.0	41.391474	2.165784	0.0	-1.0	41.391553

	long_1	collision_1	victim_id_1	lat_2	…	victim_id_22	lat_23	\
83	2.165712	0.0	-1.0	41.391101	…	-1.0	41.392022	
170	2.163291	0.0	-1.0	41.391353	…	-1.0	41.392811	
167	2.162785	0.0	-1.0	41.388985	…	-1.0	41.389914	
101	2.164133	0.0	-1.0	41.391561	…	-1.0	41.391358	
51	2.165018	0.0	-1.0	41.392103	…	-1.0	41.39142	
180	2.164978	0.0	-1.0	41.39059	…	-1.0	41.391446	
162	2.163621	0.0	-1.0	41.393194	…	-1.0	41.392572	
27	2.165349	0.0	-1.0	41.391999	…	-1.0	41.392965	
170	2.163408	0.0	-1.0	41.393364	…	-1.0	41.392871	
106	2.165496	0.0	-1.0	41.391832	…	-1.0	41.392753	
147	2.164762	0.0	-1.0	41.390261	…	-1.0	41.39057	
163	2.166142	0.0	-1.0	41.39297	…	-1.0	41.391593	
166	2.162796	0.0	-1.0	41.389199	…	-1.0	41.389965	
156	2.163595	0.0	-1.0	41.393017	…	-1.0	41.392426	
156	2.161959	0.0	-1.0	41.391724	…	-1.0	41.392882	
102	2.163644	0.0	-1.0	41.391076	…	-1.0	41.391744	
171	2.162629	0.0	-1.0	41.388876	…	-1.0	41.389971	
60	2.165538	0.0	-1.0	41.391587	…	-1.0	41.390637	
53	2.166445	0.0	-1.0	41.391167	…	-1.0	41.391858	
30	2.165685	0.0	-1.0	41.391595	…	-1.0	41.391602	

	long_23	collision_23	victim_id_23	lat_24	long_24	collision_24	\
83	2.165269	0.0	-1.0	41.392061	2.165224	1.0	
170	2.163589	0.0	-1.0	41.392836	2.163624	1.0	
167	2.164129	0.0	-1.0	41.389947	2.164172	1.0	
101	2.163864	0.0	-1.0	41.391328	2.163825	1.0	
51	2.163893	0.0	-1.0	41.391388	2.16385	1.0	
180	2.165872	0.0	-1.0	41.391519	2.165832	1.0	

```
162  2.164381          0.0          -1.0  41.392535  2.164426           1.0
27    2.16411          0.0          -1.0  41.393002  2.164065           1.0
170  2.163967          0.0          -1.0  41.392843     2.164           1.0
106  2.164368          0.0          -1.0  41.392793   2.16432           1.0
147  2.164949          0.0          -1.0  41.390603  2.164993           1.0
163  2.165583          0.0          -1.0  41.391552  2.165633           1.0
166  2.164142          0.0          -1.0  41.390012  2.164204           1.0
156  2.164506          0.0          -1.0  41.392386  2.164555           1.0
156  2.163522          0.0          -1.0    41.3929  2.163547           1.0
102  2.162681          0.0          -1.0  41.391782  2.162631           1.0
171   2.16415          0.0          -1.0  41.390015  2.164208           1.0
60   2.166713          0.0          -1.0  41.390597  2.166762           1.0
53    2.16536          0.0          -1.0  41.391887  2.165326           1.0
30   2.164188          0.0          -1.0  41.391554  2.164123           1.0

    victim_id_24                 df_time
83        1162.0  df_collisions_1033_1058
170       1541.0  df_collisions_1508_1533
167       2104.0  df_collisions_2233_2258
101       2274.0  df_collisions_2558_2583
51        2701.0  df_collisions_3433_3458
180       3802.0  df_collisions_4133_4158
162       3967.0  df_collisions_4333_4358
27        4079.0  df_collisions_4833_4858
170       4621.0  df_collisions_5058_5083
106       4301.0  df_collisions_5133_5158
147       4711.0  df_collisions_5158_5183
163       4848.0  df_collisions_5408_5433
166       5556.0  df_collisions_6258_6283
156       5873.0  df_collisions_6758_6783
156       6491.0  df_collisions_7583_7608
102       6962.0  df_collisions_8183_8208
171       7400.0  df_collisions_8783_8808
60        7648.0  df_collisions_9258_9283
53        8145.0  df_collisions_9858_9883
30        7689.0  df_collisions_9908_9933

[20 rows x 102 columns]
```

4.0.5 Probabilidad de colisión

[445]:
```python
def get_df_collision_risk(vehicles_list, df_preds, df_full):
    risk_list = []
    collision_list = []
    columns_list = ['vehicle_id']
    columns_list.extend(vehicles_list)
    for i in range(len(vehicles_list)):
```

```
        is_colision_data = []
        colision_risk_data = []
        vehicle1 = df_preds.iloc[i]
        vehicle1_id = int(df_full.iloc[i]['vehicle_id'])
        is_colision_data.append(vehicle1_id)
        colision_risk_data.append(vehicle1_id)

        for j in range(len(vehicles_list)):
            if i!=j:
                vehicle2 = df_preds.iloc[j]
                colision, map, collision_risk, time = is_colision(vehicle1,␣
↪vehicle2)
                is_colision_data.append(colision)
                colision_risk_data.append(collision_risk)
            else:
                is_colision_data.append(-1)
                colision_risk_data.append(-1)

        collision_list.append(is_colision_data)
        risk_list.append(colision_risk_data)
    df_is_collision_1to1 = pd.DataFrame(collision_list, columns=columns_list)
    df_collision_risk_1to1 = pd.DataFrame(risk_list, columns=columns_list)
    return df_is_collision_1to1, df_collision_risk_1to1
```

[446]:
```
df_is_collision_1to1 = {}
df_collision_risk_1to1 = {}
for key in df_predictions.keys():
    print(key)
    vehicles_list = list(df_colls[key]['vehicle_id'].astype(int))
    preds_df = df_predictions[key]
    full_df = df_colls[key]
    df_is_collision_1to1[key], df_collision_risk_1to1[key] =␣
↪get_df_collision_risk(vehicles_list, preds_df, full_df)
```

```
df_collisions_1033_1058
df_collisions_1508_1533
df_collisions_2233_2258
df_collisions_2558_2583
df_collisions_3433_3458
df_collisions_4133_4158
df_collisions_4333_4358
df_collisions_4833_4858
df_collisions_5058_5083
df_collisions_5133_5158
df_collisions_5158_5183
df_collisions_5408_5433
df_collisions_6258_6283
df_collisions_6758_6783
```

```
df_collisions_7583_7608
df_collisions_8183_8208
df_collisions_8783_8808
df_collisions_9258_9283
df_collisions_9858_9883
df_collisions_9908_9933
```

[447]:
```python
import pickle
with open('df_is_collision_1to1_tree.pickle', 'wb') as f:
    pickle.dump(df_is_collision_1to1, f)

with open('df_collision_risk_1to1_tree.pickle', 'wb') as f:
    pickle.dump(df_collision_risk_1to1, f)
```

4.0.6 Comprobación colisiones Extra Tree Regressor

[448]:
```python
file = open('df_is_collision_1to1_tree.pickle', 'rb')
df_is_collision_1to1 = pickle.load(file)
file.close()

file = open('df_collision_risk_1to1_tree.pickle', 'rb')
df_collision_risk_1to1 = pickle.load(file)
file.close()
```

[482]:
```python
df_is_collision_1to1['df_collisions_1033_1058']
```

[482]:
```
     vehicle_id    157    158    171    176    197    433    465    503  \
0           157     -1  False  False  False  False  False  False  False
1           158  False     -1  False  False  False  False  False  False
2           171  False  False     -1  False  False  False  False  False
3           176  False  False  False     -1  False  False  False  False
4           197  False  False  False  False     -1  False  False  False
..          …      …     …     …     …     …     …     …     …
191        1233  False  False  False  False  False  False  False  False
192        1234  False  False  False  False  False  False  False  False
193        1235  False  False  False  False  False  False  False  False
194        1236  False  False  False  False  False  False  False  False
195        1237  False  False  False  False  False  False  False  False

       515  …   1225   1227   1228   1230   1232   1233   1234   1235  \
0    False  …  False  False  False  False  False  False  False  False
1    False  …  False  False  False  False  False  False  False  False
2    False  …  False  False  False  False  False  False  False  False
3    False  …  False  False  False  False  False  False  False  False
4    False  …  False  False  False  False  False  False  False  False
..     …  …     …     …     …     …     …     …     …     …
191  False  …  False  False  False  False  False     -1  False  False
```

```
192  False  …  False  False  False  False  False  False     -1  False
193  False  …  False  False  False  False  False  False  False     -1
194  False  …  False  False  False  False  False  False  False  False
195  False  …  False  False  False  False  False  False  False  False

      1236   1237
0    False  False
1    False  False
2    False  False
3    False  False
4    False  False
..     …      …
191  False  False
192  False  False
193  False  False
194     -1  False
195  False     -1

[196 rows x 197 columns]
```

[436]:

```python
pred_collisions_df = pd.DataFrame(columns=['vehicle_id', 'victim_id',␣
 ↪'df_time'])
pred_collisions = []
for key in df_is_collision_1to1.keys():
    curr_df = df_is_collision_1to1[key]
    for index, row in curr_df.iterrows():
        for col in curr_df.columns:
            if row[col] == True:
                row_vehicle = row['vehicle_id']
                row_victim = col
                row_time = key
                pred_collisions.append([row_vehicle, row_victim, row_time])
```

[ ]:

```python
print(f"Total predicted collisions: {len(pred_collisions)/2}")
```

[437]:

```python
tp = 0
for vehicle_collisioned in pred_collisions:
    if vehicle_collisioned[0] in list(real_collisions_df['vehicle_id']):
        print(vehicle_collisioned)
        tp += 1
fp = int((len(pred_collisions) - 2*tp)/2)
fn = len(real_collisions_df)-tp

tn = 0
for key in df_is_collision_1to1.keys():
```

```
    tn += (df_is_collision_1to1[key].shape[0]*(df_is_collision_1to1[key].
 ↪shape[1]-2))/2-tp-fp-fn
print(f"True positives: {tp}")
print(f"False positives: {fp}")
print(f"True negatives: {tn}")
print(f"False negatives: {fn}")
```

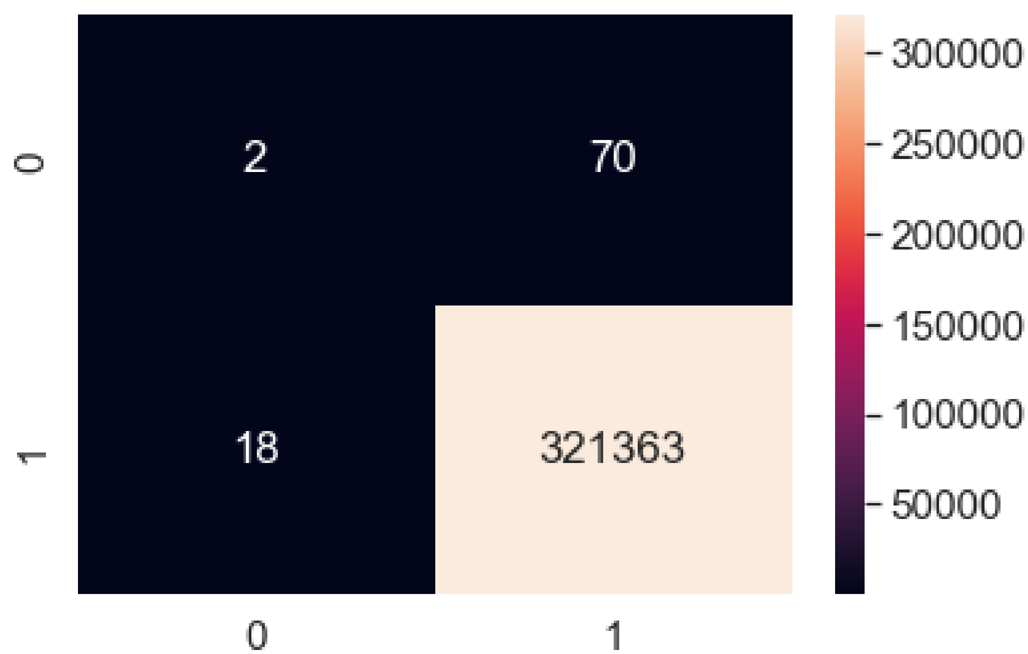
```
[1053, 157, 'df_collisions_1033_1058']
[3985, 4292, 'df_collisions_4833_4858']
True positives: 2
False positives: 70
True negatives: 651038
False negatives: 18
```

[487]:
```
confusion_matrix = [[tp, fp], [fn, tn]]
```

[488]:
```
confusion_matrix
```

[488]:
```
[[2, 70], [18, 321363]]
```

[489]:
```
import seaborn as sn
df_cm = pd.DataFrame(confusion_matrix)
sn.heatmap(df_cm, annot=True, fmt='g')
plt.show()
```



```
[490]: accuracy = (tn+tp)/(tn+fp+tp+fn)
precision = tp/(tp+fp)
recall = tp/(tp+fn)
f1_score = 2*((precision*recall)/(precision+recall))
print(f"Accuracy: {accuracy}")
print(f"Precision: {precision}")
print(f"Recall: {recall}")
print(f"F1 score: {f1_score}")
```

```
Accuracy: 0.9997262430277521
Precision: 0.027777777777777776
Recall: 0.1
F1 score: 0.043478260869565 22
```

4.0.7 Resultados probabilidad de colisión

```
[ ]: real_collisions_df
```

```
[449]: real_collisions_df_prob = real_collisions_df[['vehicle_id', 'df_time',␣
    ↪'victim_id_15', 'victim_id_16', 'victim_id_17',
                                              'victim_id_18', 'victim_id_19',␣
    ↪'victim_id_20', 'victim_id_21',
                                              'victim_id_22', 'victim_id_23',␣
    ↪'victim_id_24']]
real_collisions_prob_vehicle = list(real_collisions_df_prob['vehicle_id'])
real_collisions_prob_victim = list(real_collisions_df_prob['victim_id_24'])
real_collisions_prob_time = list(real_collisions_df_prob['df_time'])
```

4.1 Gaussian Process Regressor

```
[ ]:
```

```
[453]: from sklearn.gaussian_process import GaussianProcessRegressor
df_predictions ={}
for key in data_colls.keys():
    model = GaussianProcessRegressor()
    df_predictions[key] = call_get_next_10_positions_res(data_colls[key], model)
```

4.1.1 Probabilidad de colisión (Gaussian Process Regressor)

```
[454]: df_is_collision_1to1 = {}
df_collision_risk_1to1 = {}
for key in df_predictions.keys():
    print(key)
    vehicles_list = list(df_colls[key]['vehicle_id'].astype(int))
    preds_df = df_predictions[key]
    full_df = df_colls[key]
```

```
    df_is_collision_1to1[key], df_collision_risk_1to1[key] =␣
↪get_df_collision_risk(vehicles_list, preds_df, full_df)
```

```
df_collisions_1033_1058
df_collisions_1508_1533
df_collisions_2233_2258
df_collisions_2558_2583
df_collisions_3433_3458
df_collisions_4133_4158
df_collisions_4333_4358
df_collisions_4833_4858
df_collisions_5058_5083
df_collisions_5133_5158
df_collisions_5158_5183
df_collisions_5408_5433
df_collisions_6258_6283
df_collisions_6758_6783
df_collisions_7583_7608
df_collisions_8183_8208
df_collisions_8783_8808
df_collisions_9258_9283
df_collisions_9858_9883
df_collisions_9908_9933
```

[455]:
```
import pickle
with open('df_is_collision_1to1_gauss.pickle', 'wb') as f:
    pickle.dump(df_is_collision_1to1, f)

with open('df_collision_risk_1to1_gauss.pickle', 'wb') as f:
    pickle.dump(df_collision_risk_1to1, f)
```

4.1.2 Comprobación colisiones (Gaussian Process Regressor

[456]:
```
file = open('df_is_collision_1to1_gauss.pickle', 'rb')
df_is_collision_1to1 = pickle.load(file)
file.close()

file = open('df_collision_risk_1to1_gauss.pickle', 'rb')
df_collision_risk_1to1 = pickle.load(file)
file.close()
```

[457]:
```
pred_collisions_df = pd.DataFrame(columns=['vehicle_id', 'victim_id',␣
↪'df_time'])
pred_collisions = []
for key in df_is_collision_1to1.keys():
    curr_df = df_is_collision_1to1[key]
    for index, row in curr_df.iterrows():
```

```
        for col in curr_df.columns:
            if row[col] == True:
                row_vehicle = row['vehicle_id']
                row_victim = col
                row_time = key
                pred_collisions.append([row_vehicle, row_victim, row_time])
```

[458]:
```
print(f"Total predicted collisions: {len(pred_collisions)/2}")
```

```
Total predicted collisions: 199.0
```

[466]:
```
tp = 0
for vehicle_collisioned in pred_collisions:
    if vehicle_collisioned[0] in list(real_collisions_df['vehicle_id']):
        tp += 1
fp = int((len(pred_collisions) - 2*tp)/2)
fn = len(real_collisions_df)-tp

tn = 0
for key in df_is_collision_1to1.keys():
    tn += (df_is_collision_1to1[key].shape[0]*(df_is_collision_1to1[key].
 ↪shape[1]-2))/2-tp-fp-fn
print(f"True positives: {tp}")
print(f"False positives: {fp}")
print(f"True negatives: {tn}")
print(f"False negatives: {fn}")
```

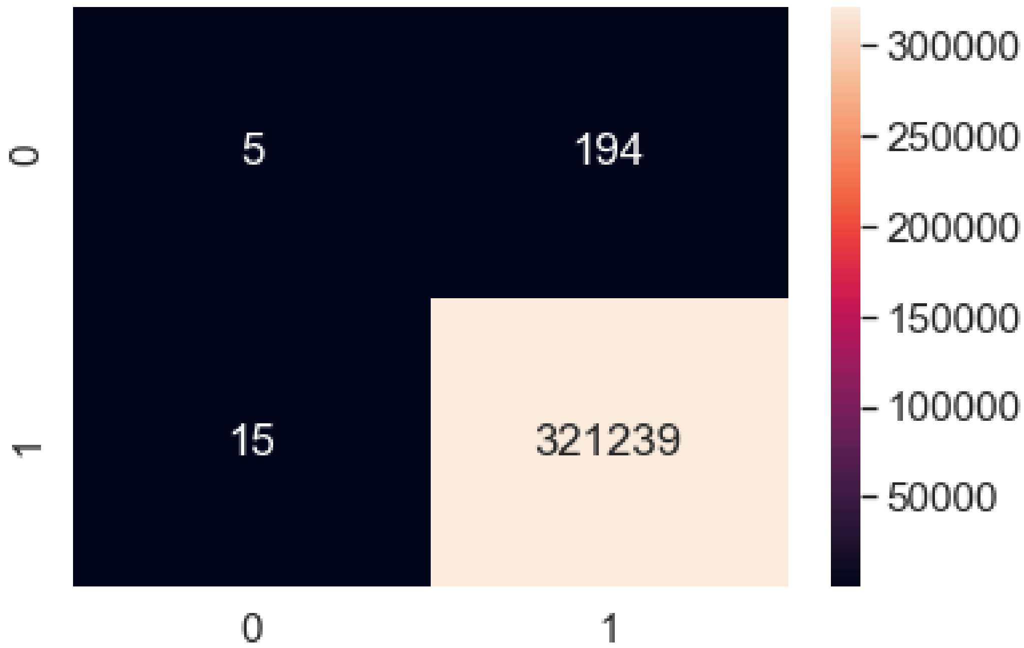
```
True positives: 5
False positives: 194
True negatives: 321239.0
False negatives: 15
```

[467]:
```
confusion_matrix = [[tp, fp], [fn, tn]]
```

[468]:
```
confusion_matrix
```

[468]:
```
[[5, 194], [15, 321239.0]]
```

[469]:
```
import seaborn as sn
df_cm = pd.DataFrame(confusion_matrix)
sn.heatmap(df_cm, annot=True, fmt='g')
plt.show()
```



[479]:
```
accuracy = (tn+tp)/(tn+fp+tp+fn)
precision = tp/(tp+fp)
recall = tp/(tp+fn)
f1_score = 2*((precision*recall)/(precision+recall))
print(f"Accuracy: {accuracy}")
print(f"Precision: {precision}")
print(f"Recall: {recall}")
print(f"F1 score: {f1_score}")
```

```
Accuracy: 0.9997262430277521
Precision: 0.027777777777777776
Recall: 0.1
F1 score: 0.043478260869565222
```