Drone classification with trajectories :
identifying drones in the Russian-Ukrainian war

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20/12/2024


Introduction

UAVs as a newborn tool in modern warfare

INTERNATIONAL • WAR IN UKRAINE

Musk says Starlink stopped a Ukraine drone attack on Russian fleet

The tech billionaire Elon Musk says that his company SpaceX was asked to activate its satellite internet service Starlink in the Black Sea, to enable a Ukrainian attack on Russia's fleet.

Le Monde with AFP

Published on September 8, 2023, at 3:40 pm (Paris), updated on September 8, 2023, at 3:48 pm • 1 min read

Ukrainian naval drone with a Starlink terminal

Starlink potential role over the conflict

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Un terminal Starlink repéré sur un drone militaire russe intercepté par l'Ukraine

Une utilisation illicite qui en fait une arme de destruction encore plus efficace...

Valisoa Rasolofo & J. Paiano · 30 septembre 2024

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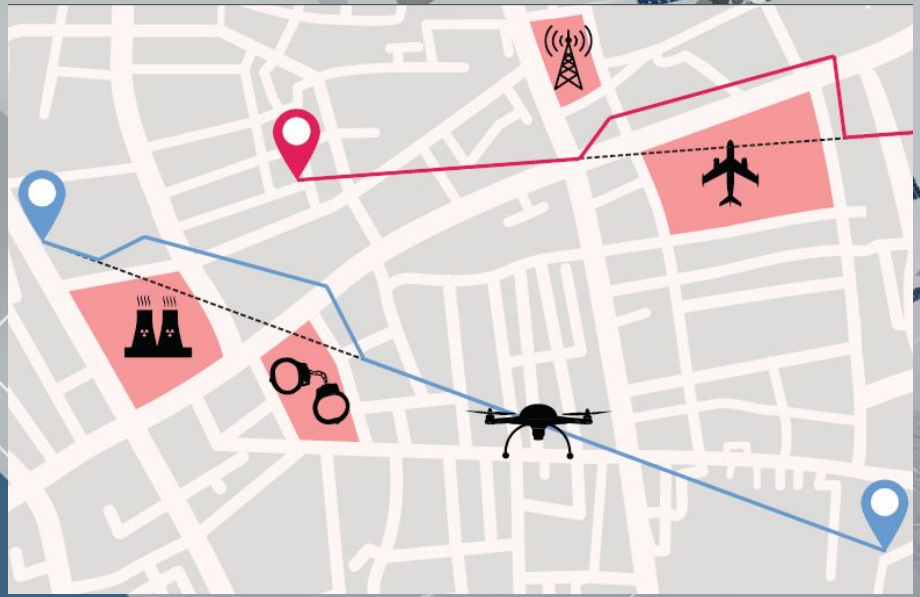
Starlink potential role over the conflict

What implies geofencing ?



Number of Suicide-Drones shot down (daily)

Methods

OSINT

ORYX

List Of Aircraft Losses During The Russian Invasion Of Ukraine

Oryx Sunday, March 20, 2022 Aircraft Losses , Bayraktar TB2 0 Comments

SEARCH

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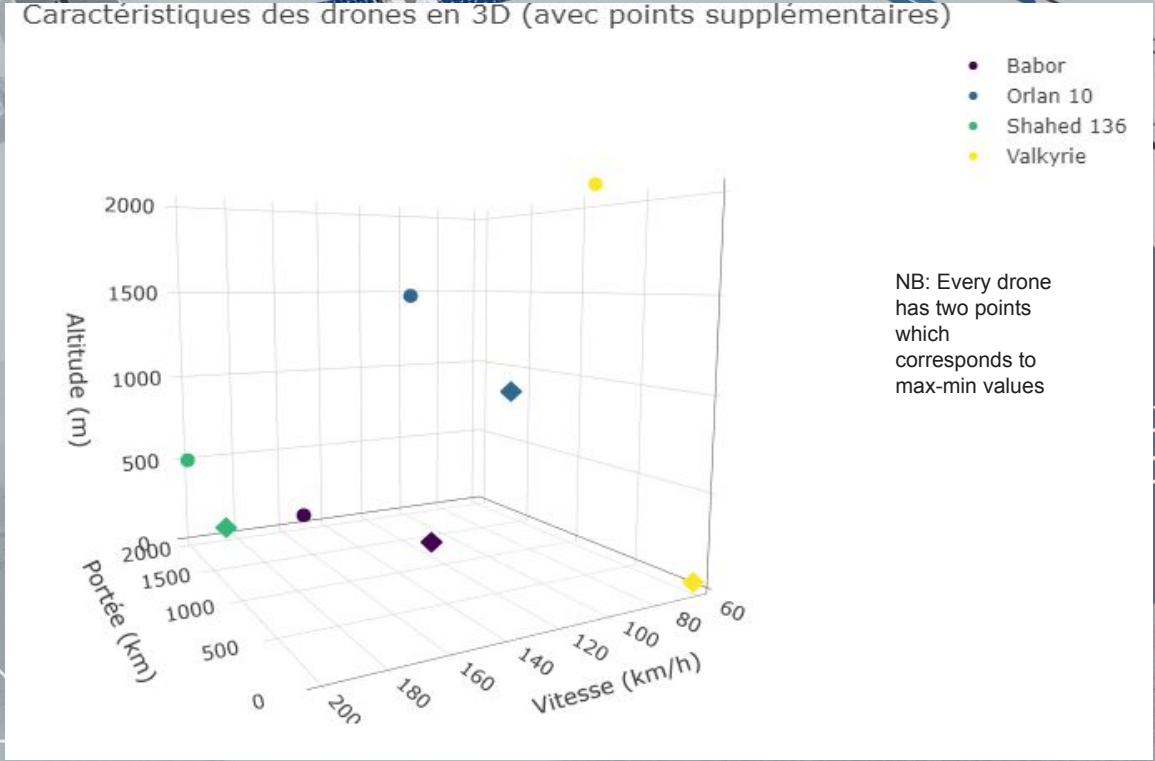
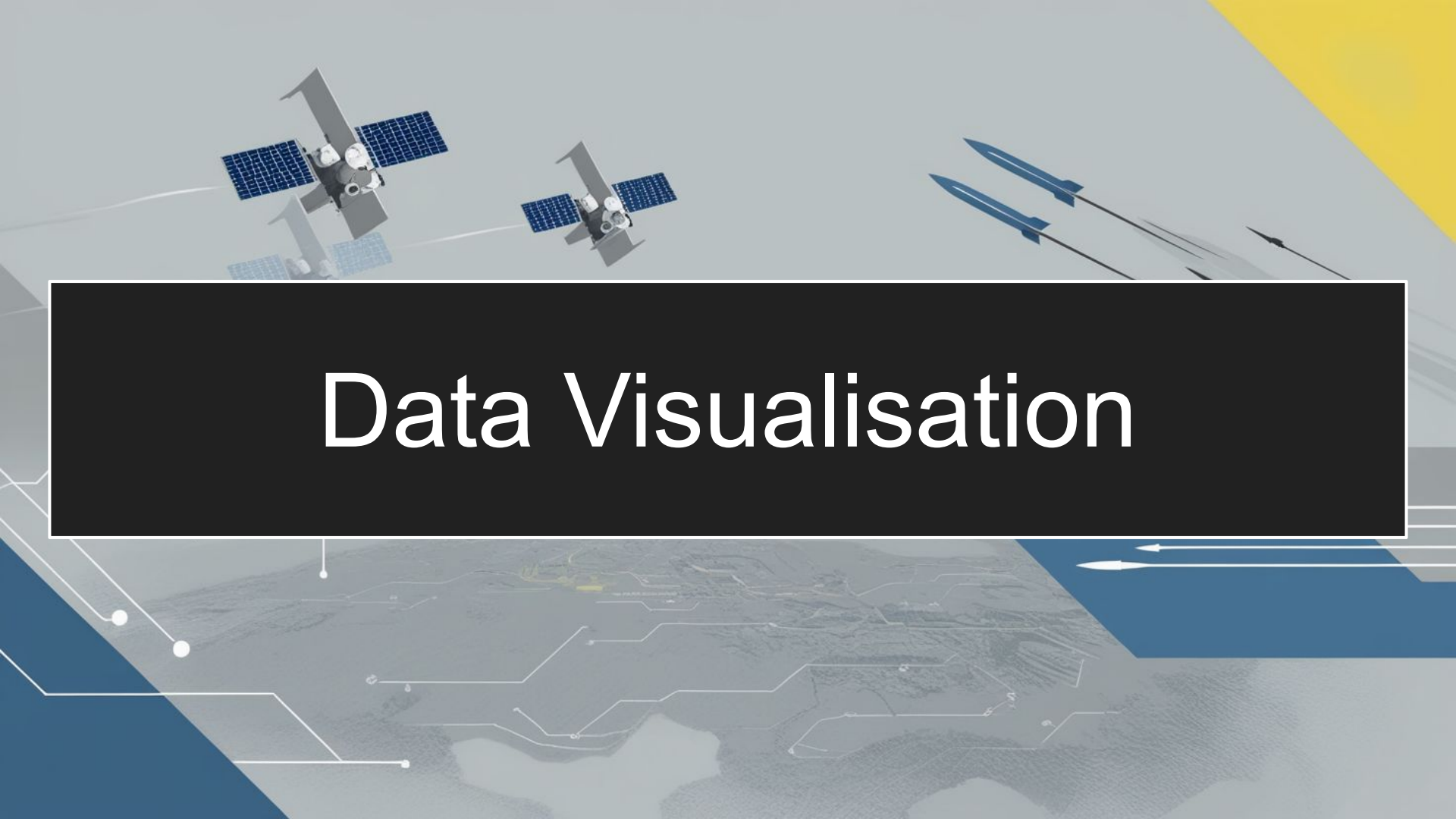
Collecting and process data

	Nom	Origine	Type	Altitudemax	Vitessemax	Range.km	Altitudemin	Cruisespeed.km	usualrange.km
1	Shahed 136	Russe	Suicide	500	200	2000	50	185	1000
2	Orlan 10	Russe	Reconnaissance	1500	150	600	1000	110	110
3	Babor	Ukrainien	Suicide	400	180	900	150	130	300
4	Valkyrie	Ukrainien	Reconnaissance	2000	108	34	30	60	34

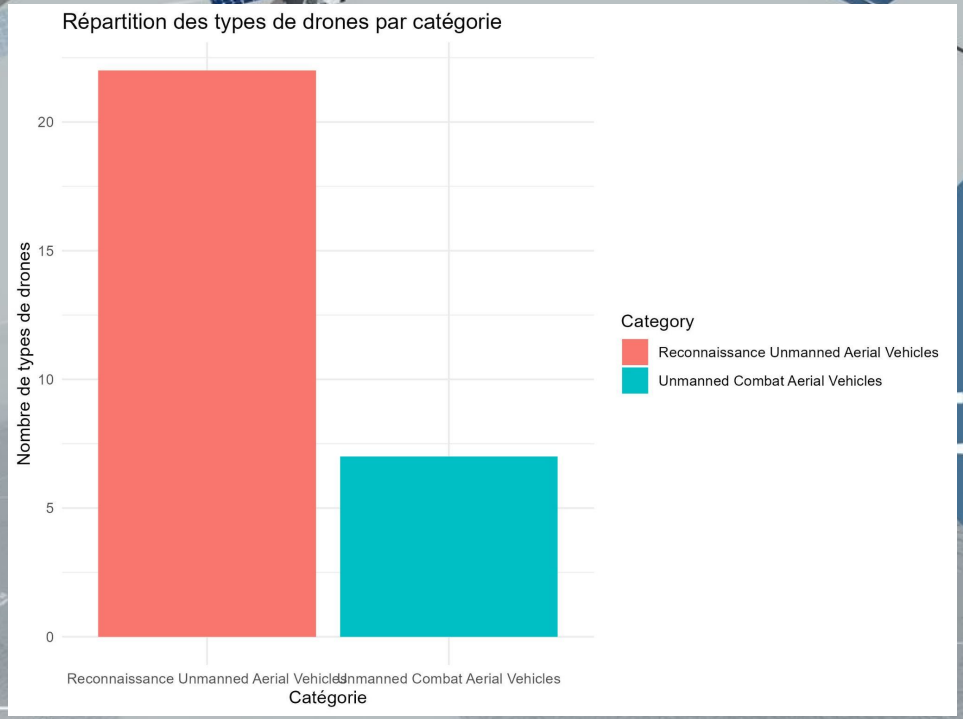
Analysing data



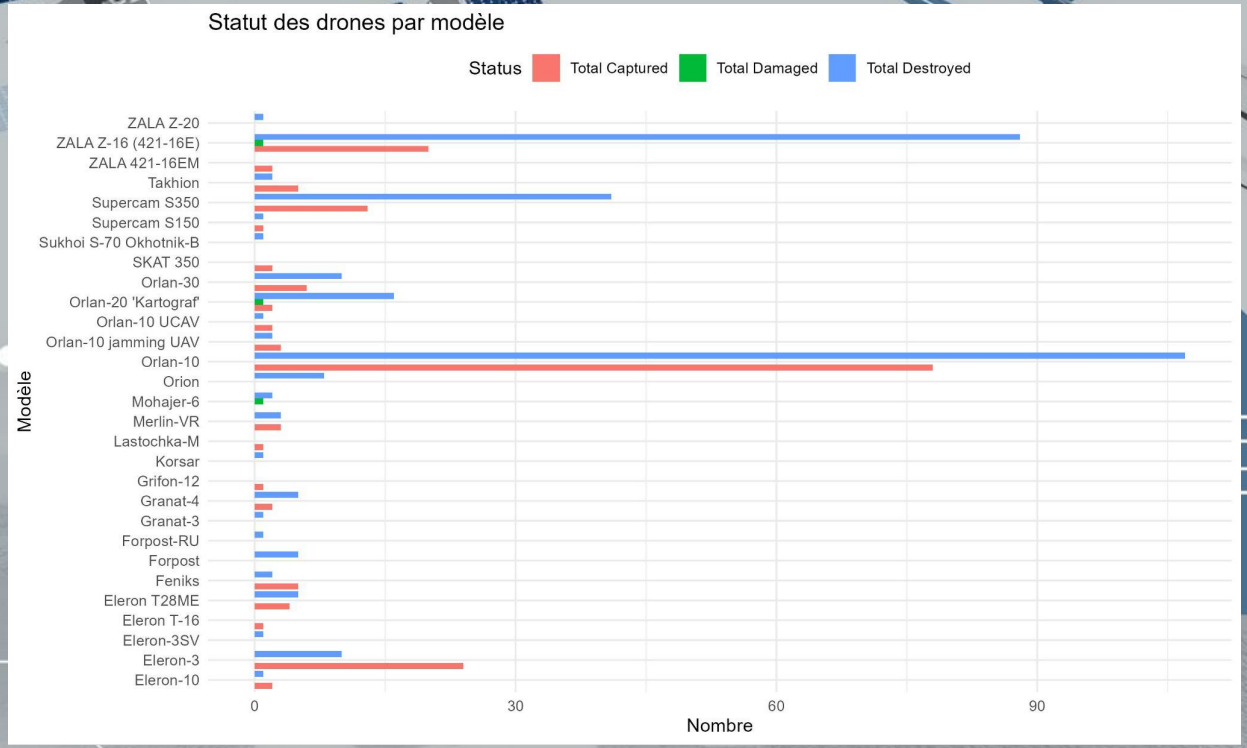
NB: Every drone has two points which corresponds to max-min values


Data Visualisation

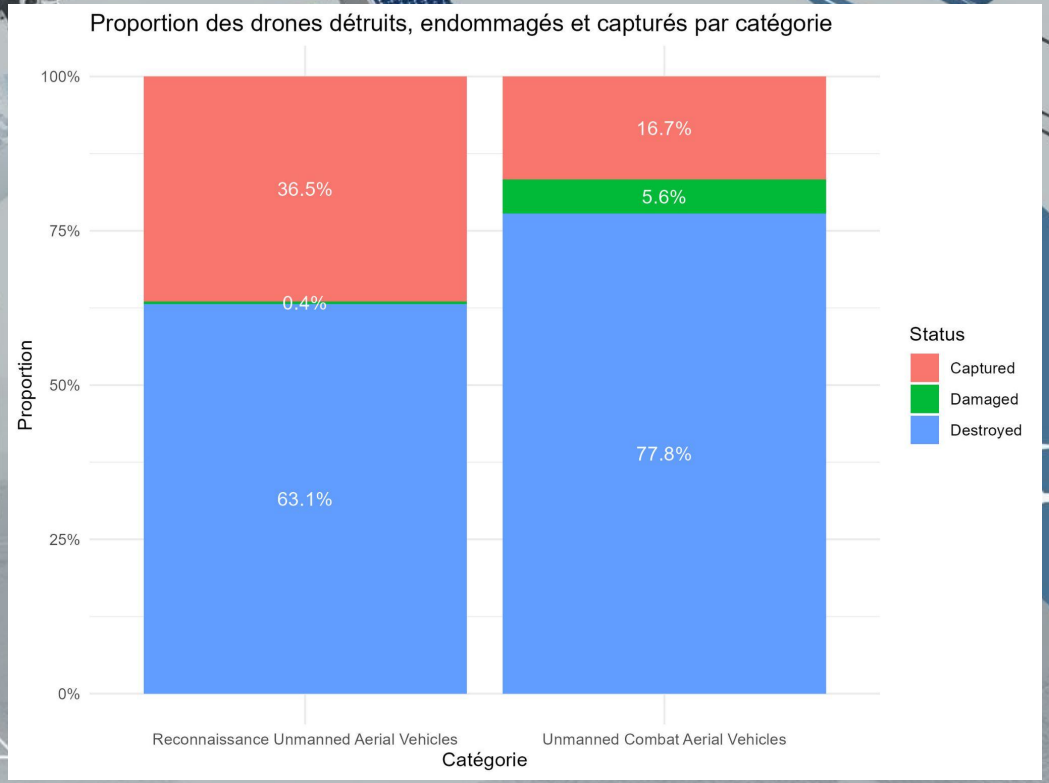
Number of Drones by type



Number of Suicide-Drones shot down



Number of Suicide-Drones shot down



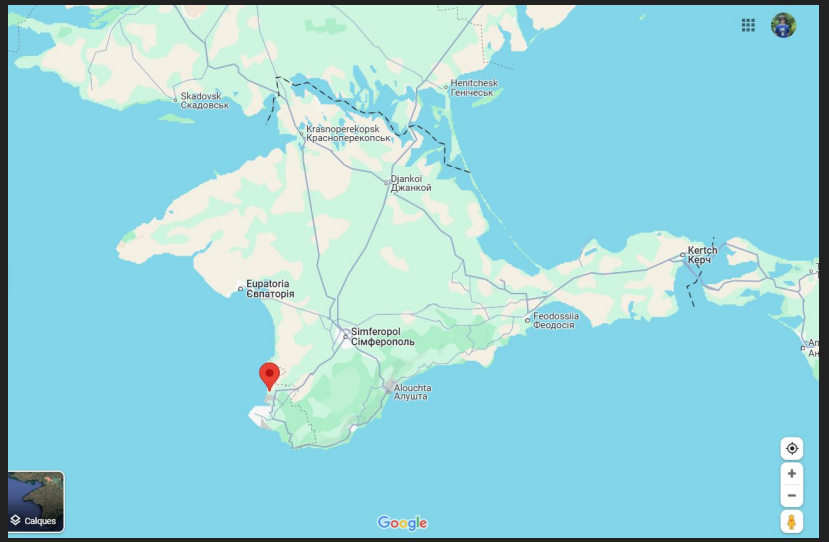
Framing of issue

How to know if the drone is Russian or Ukrainian ?

Synopsis: The aim is to create an algorithm capable of detecting whether a drone is a “reconnaissance drone” or a “suicide drone” and if it is a Russian or Ukrainian. To achieve this, we will use Machine Learning

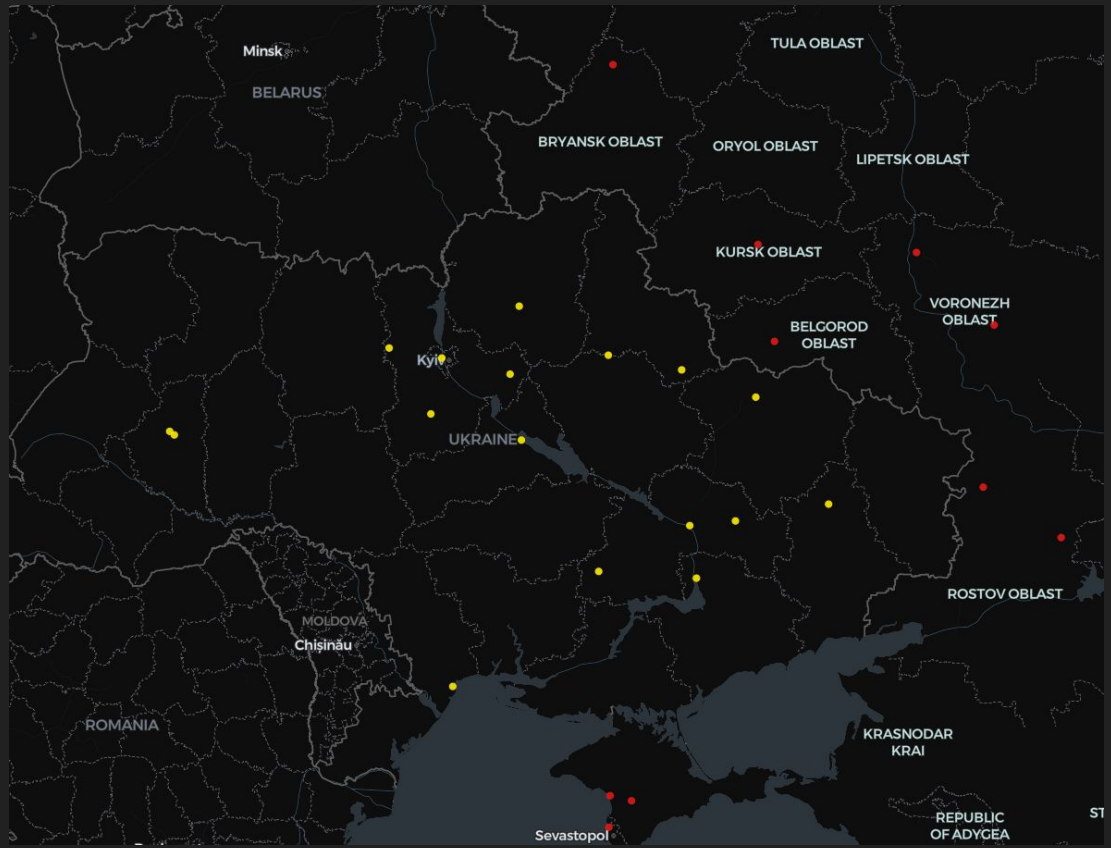
Type	Russian		Ukrainian	
Suicide	Shahed-136		Babor	
Recon	Orlan-10		Valkyrie	

Locate major Russian air bases

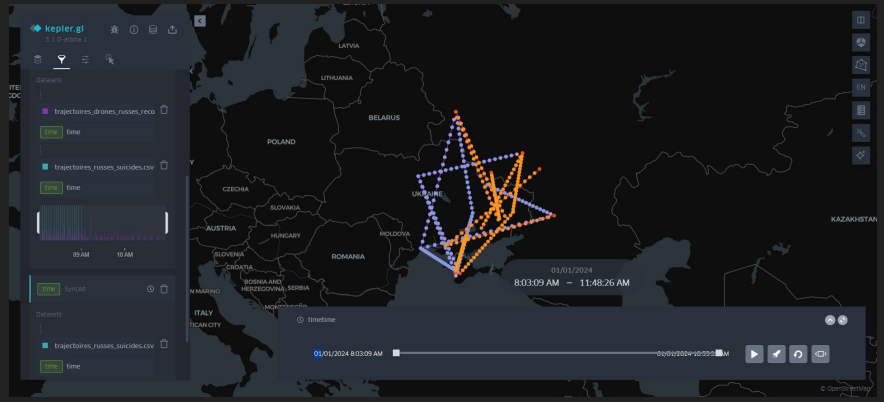


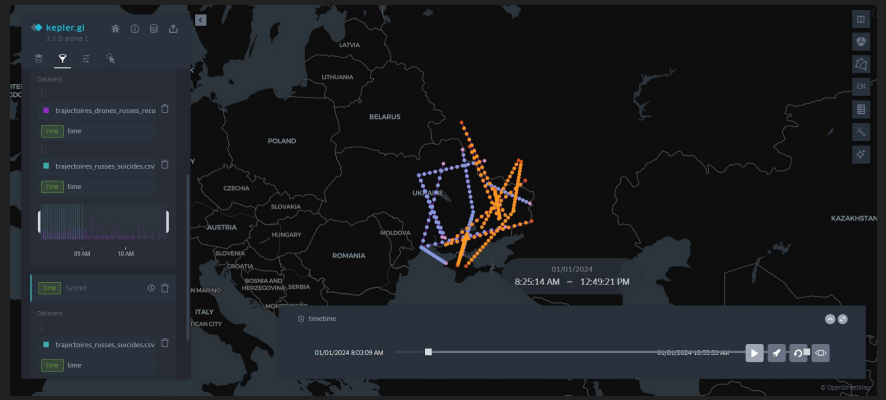
Satellite image ©2024 Maxar Technologies

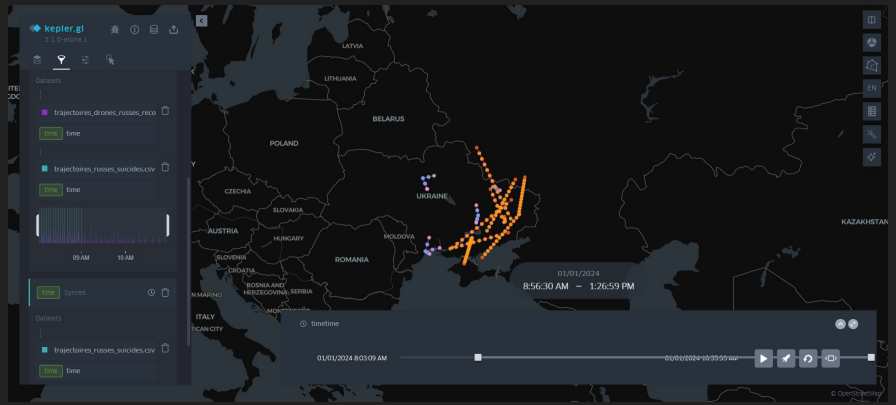
Location of russian air bases & ukrainian cities

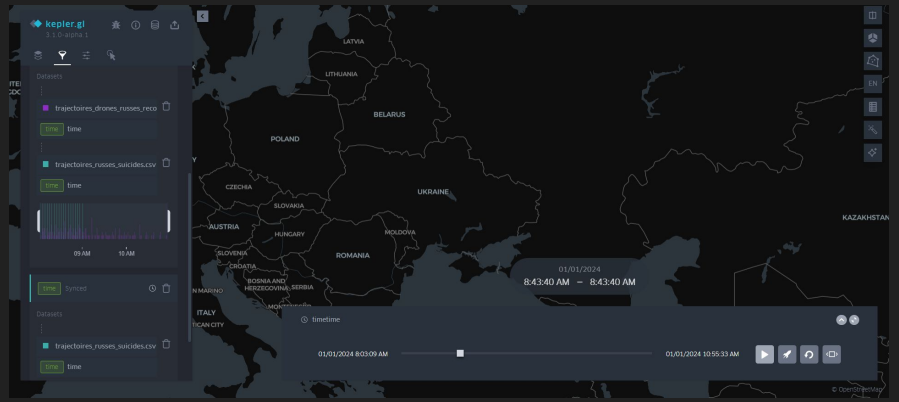


Simulation of trajectories



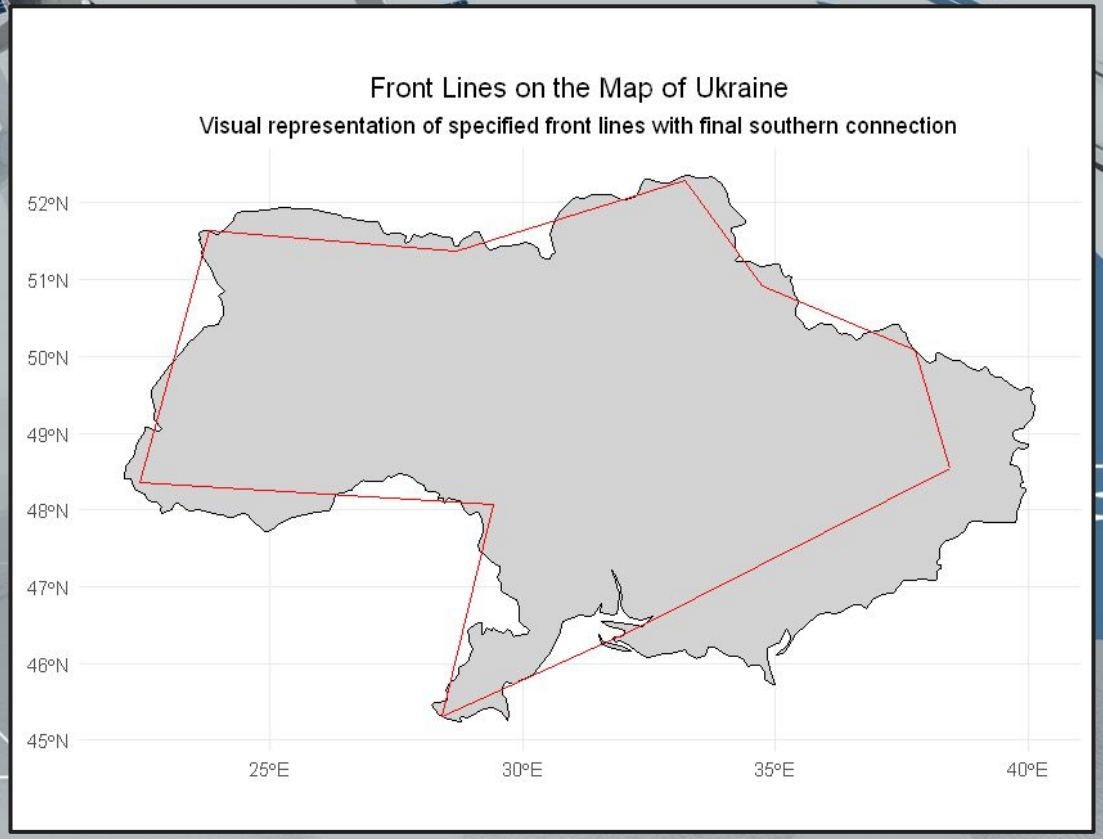


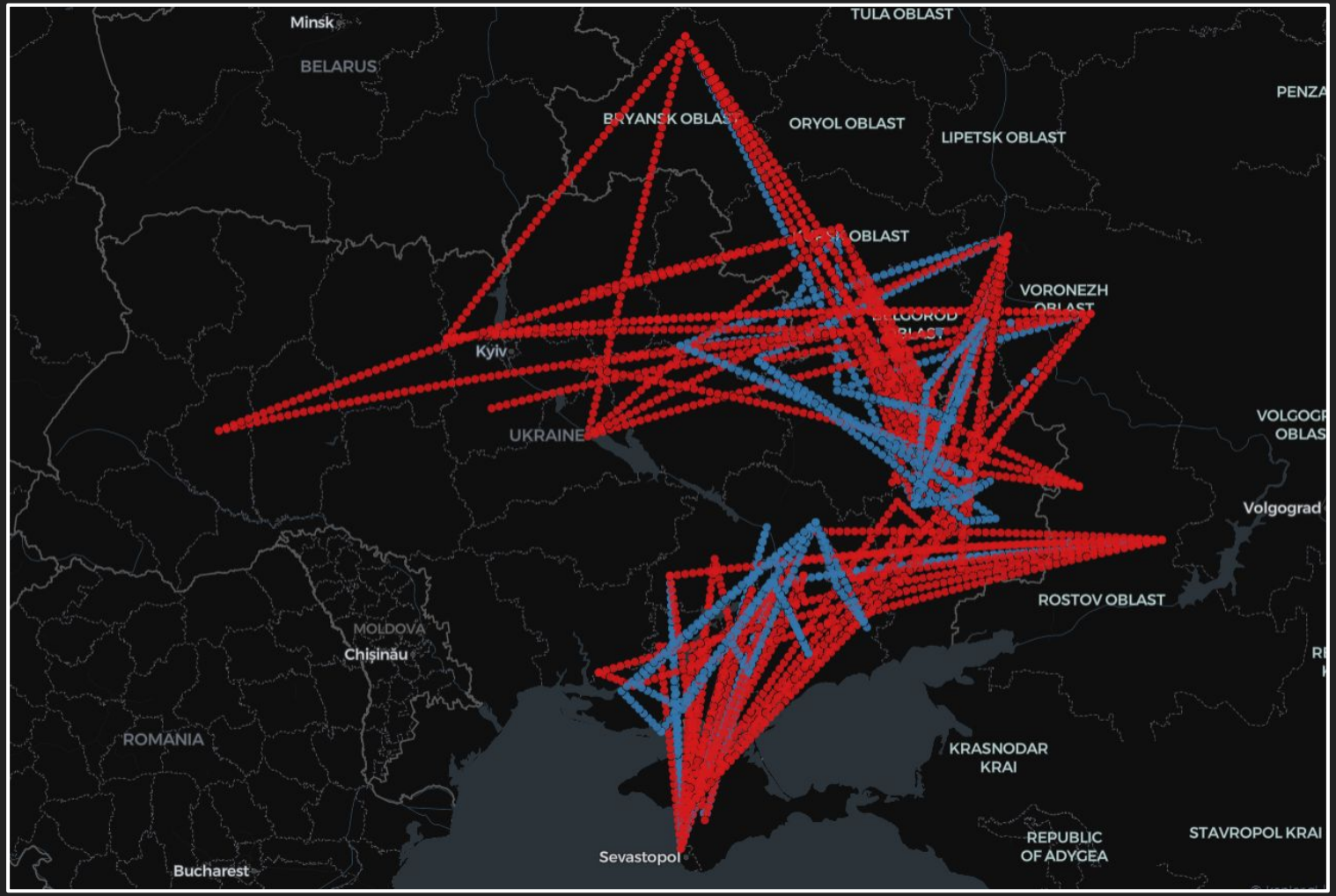





Trajectory Classification

Polygon Representation




Minsk
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TULA OBLAST
PENZA
BRYANSK OBLAST
ORYOL OBLAST
LIPETSK OBLAST
VORONEZH OBLAST
Kyiv
UKRAINE
VOLGOGR OBLAS
Volgograd
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ROMANIA
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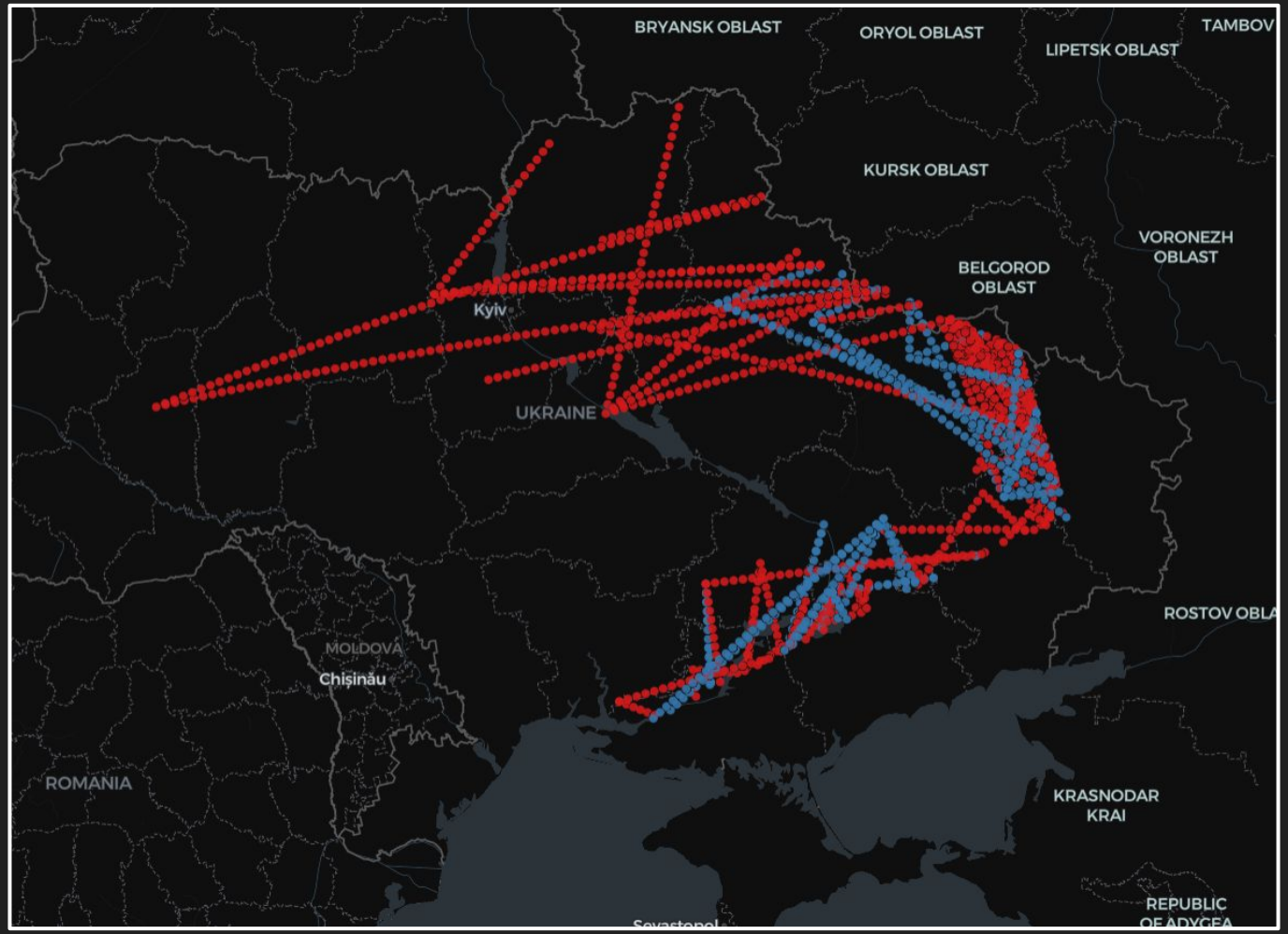
Bucharest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Kyiv
UKRAINE
ROSTOV OBLA
MOLDOVA
Chișinău
ROMANIA
KRASNODAR KRAI
REPUBLIC OF ADYGEA

Data in entry of the Random Forest

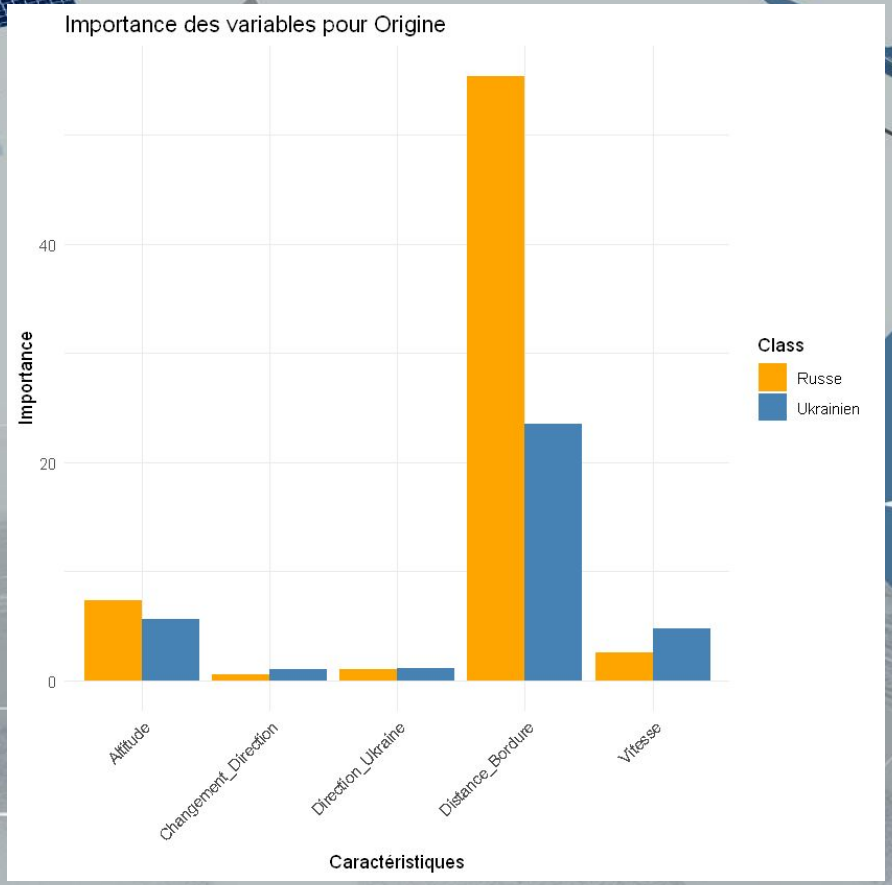
Drone_ID	Distance_Bordure	Direction_Ukraine	Changement_Direction	Origine	Type	Vitesse	Altitude
<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
Drone_1	101042.5147	0	0	0	1	88.31158	340.8203
Drone_10	32442.7783	0	1	0	1	89.15625	315.7651
Drone_100	45827.8101	0	0	0	0	113.98991	1560.3415
Drone_1000	101042.5147	0	1	0	0	112.08246	1598.4045
Drone_10000	3013.1170	1	1	1	1	105.51726	406.6410
Drone_1001	78690.1681	0	1	0	0	104.80268	1628.2067
Drone_1002	109.0453	1	0	1	1	101.09027	405.8906
Drone_1003	100153.2180	1	1	0	1	84.17521	327.5955
Drone_1004	2325.3114	1	1	1	1	100.05609	419.1397
Drone_1005	78690.1681	1	1	0	0	115.28863	1549.0462
Drone_1006	58367.6666	0	0	0	1	89.49440	307.9373
Drone_1007	514.5401	1	1	1	1	90.84235	402.8118

Result of the classification for the Drone Origin (Russian or Ukrainian)

```
### Importance des variables pour Origine #
                              0          1
Distance_Bordure     23.5249438 55.4373941
Direction_Ukraine     1.0796130  1.0030214
Changement_Direction  0.9812603  0.5608878
Vitesse               4.7618314  2.5765822
Altitude              5.6184370  7.3697696
```

```
### Évaluation du modèle pour Origine ###
Confusion Matrix and Statistics

          Reference
Prediction    0    1
         0  937    0
         1    0 1050

               Accuracy : 1
                 95% CI : (0.9981, 1)
    No Information Rate : 0.5284
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 1

 Mcnemar's Test P-Value : NA

            Sensitivity : 1.0000
            Specificity : 1.0000
         Pos Pred Value : 1.0000
         Neg Pred Value : 1.0000
             Prevalence : 0.4716
         Detection Rate : 0.4716
   Detection Prevalence : 0.4716
      Balanced Accuracy : 1.0000

       'Positive' Class : 0
```

Result of the classification for Drone Origin



Result of the classification for Drone Type (Recon or Suicide)

Importance des variables pour Type

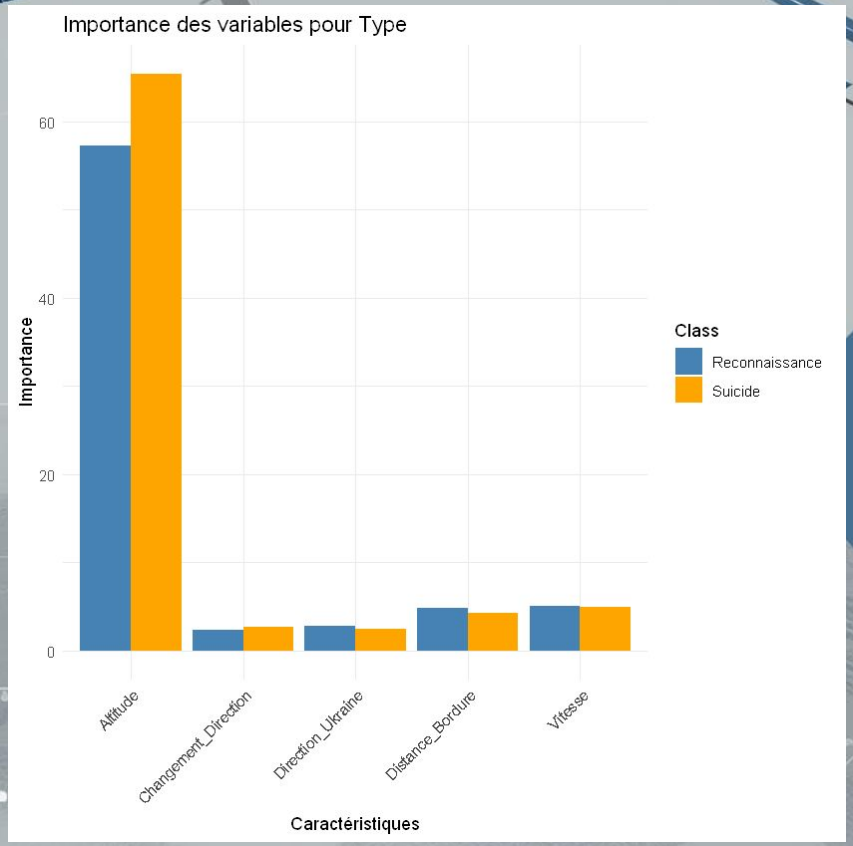
	0	1
Distance_Bordure	3.909634	4.902013
Direction_Ukraine	2.629684	2.919387
Changement_Direction	2.212913	2.802464
Premiere_Appearance	2.922433	3.298552
Vitesse	5.367764	6.341884
Altitude	36.268943	39.644906

Évaluation du modèle pour Type
Confusion Matrix and Statistics

Prediction	Reference 0	1
0	991	0
1	0	996

Accuracy	1
95% CI	(0.9981, 1)
No Information Rate	0.5013
P-Value [Acc > NIR]	< 2.2e-16
Kappa	1
Mcnemar's Test P-Value	NA
Sensitivity	1.0000
Specificity	1.0000
Pos Pred Value	1.0000
Neg Pred Value	1.0000
Prevalence	0.4987
Detection Rate	0.4987
Detection Prevalence	0.4987
Balanced Accuracy	1.0000
'Positive' Class	0

Result of the classification for Drone Type



References

- APPLEBAUM, Anne, 2023. What Russia Got by Scaring Elon Musk. *The Atlantic*. Online. 11 September 2023. Available from: https://www.theatlantic.com/ideas/archive/2023/09/elon-musk-let-russia-scare-him/675282/ [Accessed December 2024].

- PAIANO, Valisoa Rasolofo & J., 2024. Un terminal Starlink repéré sur un drone militaire russe intercepté par l'Ukraine. *Trust My Science*. Online. 30 September 2024. Available from: https://trustmyscience.com/terminal-starlink-detecte-drone-militaire-russe-intercepte-ukraine/ [Accessed November 2024].

- COOK, Ellie, Ukraine discovers Starlink on downed Russian Shahed drone: Report, 2024. *Newsweek*. Online. Available from: https://www.newsweek.com/ukraine-starlink-russia-shahed-135-drone-elon-musk-spacex-1959563 [Accessed December 2024].

- OGDEN, Theodora, 2024. The Role of the Space Domain in the Russia-Ukraine War. Centre for Emerging Technology and Security. Online. 23 Février 2024. Available from: https://cetas.turing.ac.uk/publications/role-space-domain-russia-ukraine-war [Accessed November 2024].

- A. DE FREITAS, Nicksson, COELHO DA SILVA, Ticiana, FERNANDES DE MACÊDO, José, MELO JUNIOR, Leopoldo et CORDEIRO, Matheus, 2021. Using Deep Learning for Trajectory Classification: In : Proceedings of the 13th International Conference on Agents and Artificial Intelligence. Science and Technology Publications. 2021. pp. 664-671.