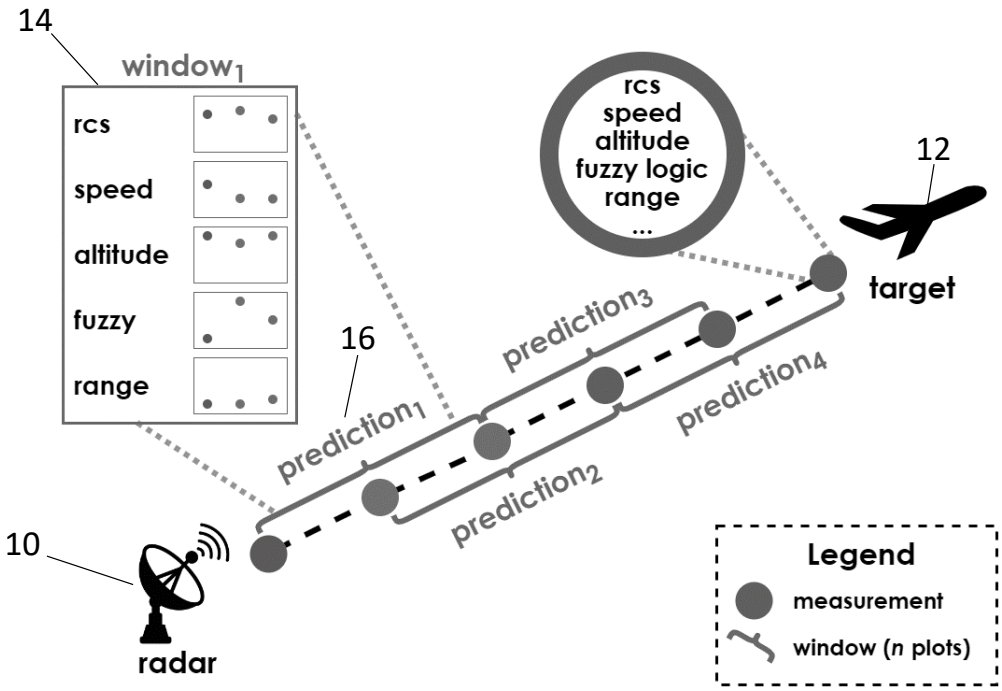
14
window1
rcs
speed
altitude
fuzzy
range
rcs
speed
altitude
fuzzy logic
range
...
12
target
16
prediction1
prediction2
prediction3
prediction4
10
radar
Legend
measurement
window (n plots)

FIG.1

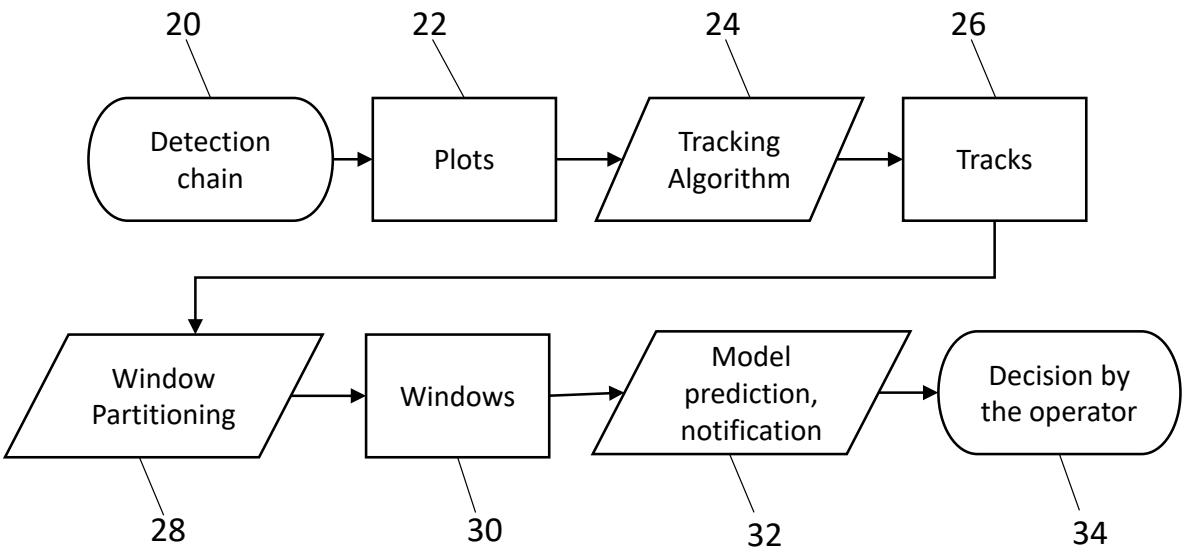
20
22
24
26
Detection chain
Plots
Tracking Algorithm
Tracks
Window Partitioning
Windows
Model prediction, notification
Decision by the operator
28
30
32
34

FIG.2

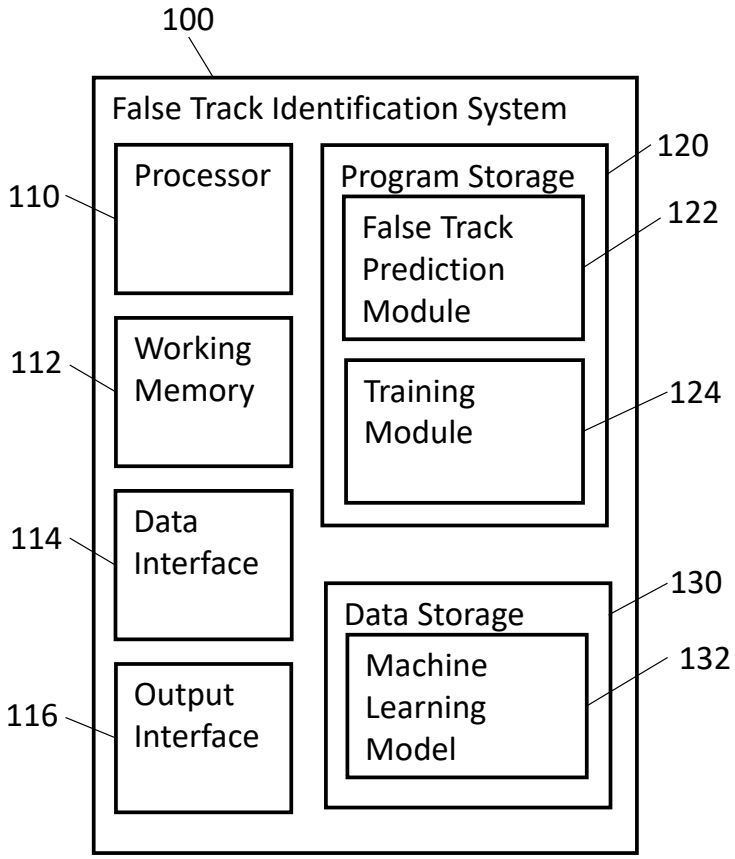
100
False Track Identification System
Processor
110
Working Memory
112
Data Interface
114
Output Interface
116
Program Storage
120
False Track Prediction Module
122
Training Module
124
Data Storage
130
Machine Learning Model
132

FIG.3

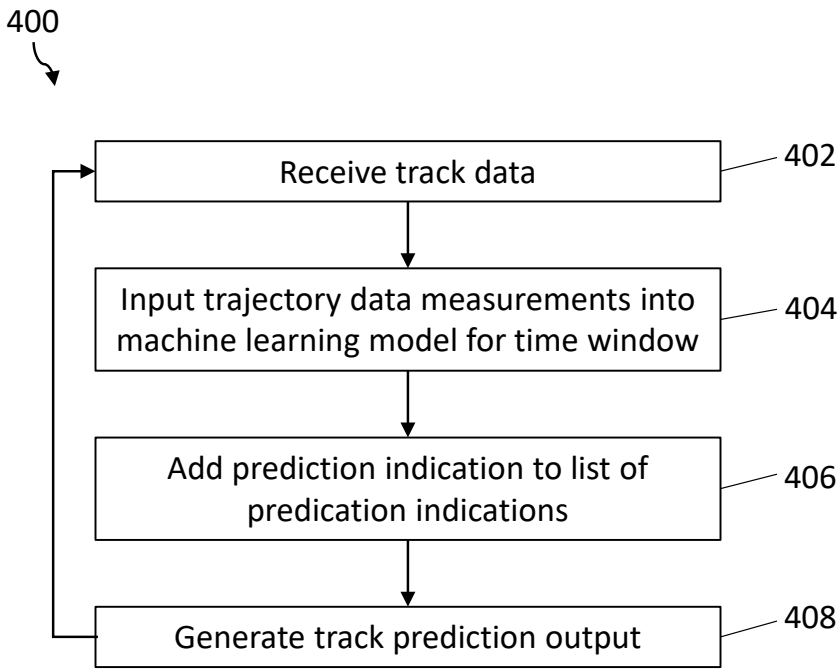
400
Receive track data
402
Input trajectory data measurements into machine learning model for time window
404
Add prediction indication to list of predication indications
406
Generate track prediction output
408

FIG.4

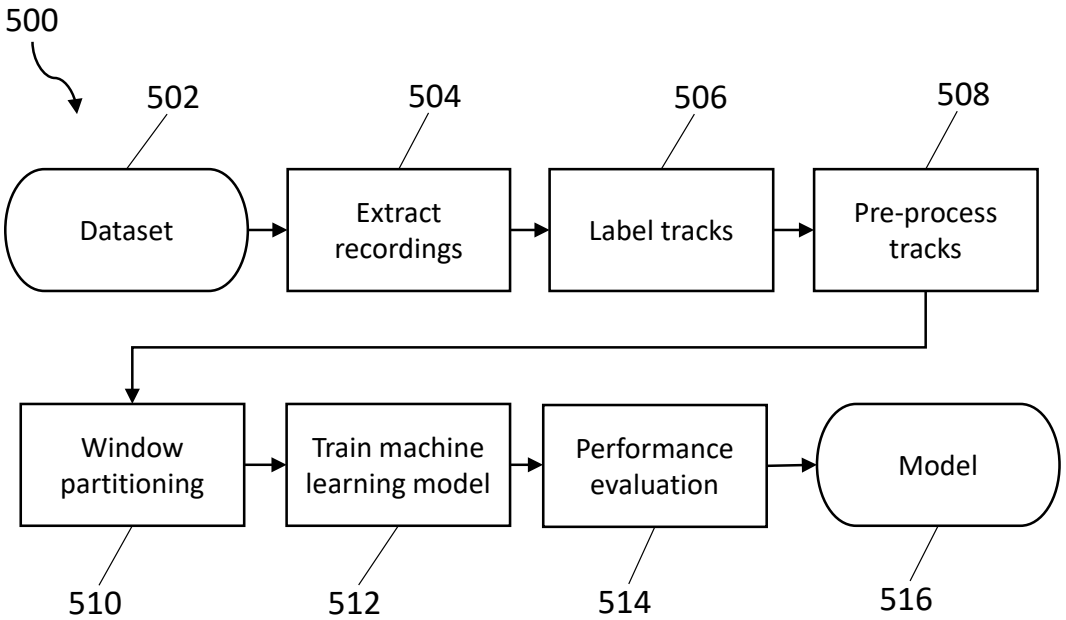
500
502
504
506
508
Dataset
Extract recordings
Label tracks
Pre-process tracks
Window partitioning
Train machine learning model
Performance evaluation
Model
510
512
514
516

FIG.5

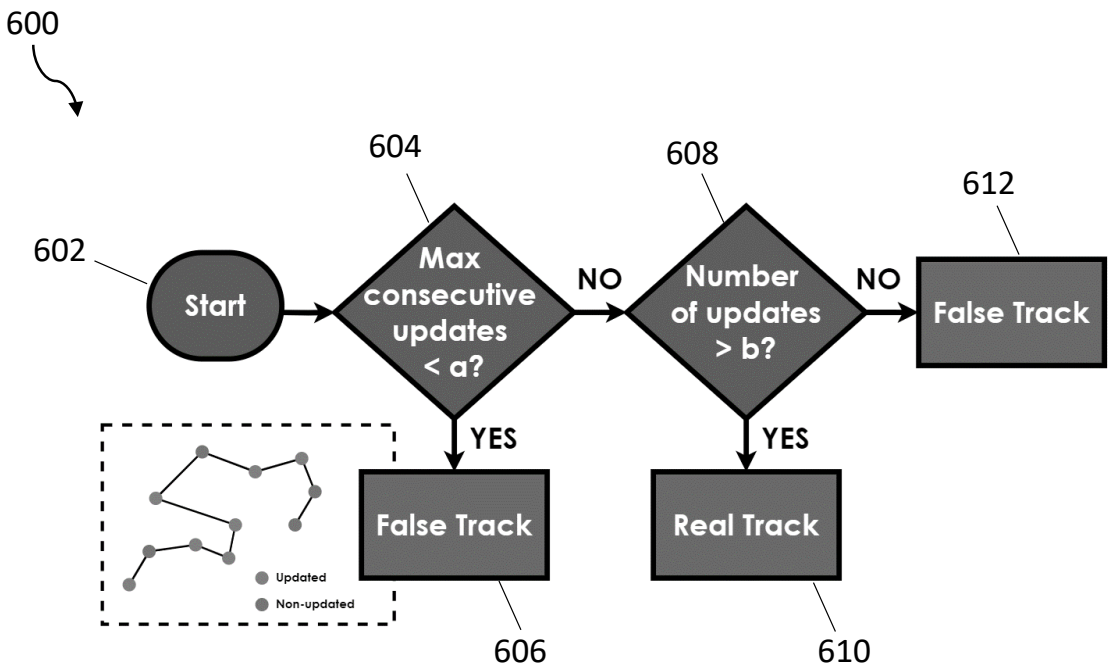
600
602
604
608
612
Start
Max consecutive updates < a?
NO
Number of updates > b?
NO
False Track
YES
YES
False Track
Real Track
Updated
Non-updated
606
610

FIG.6

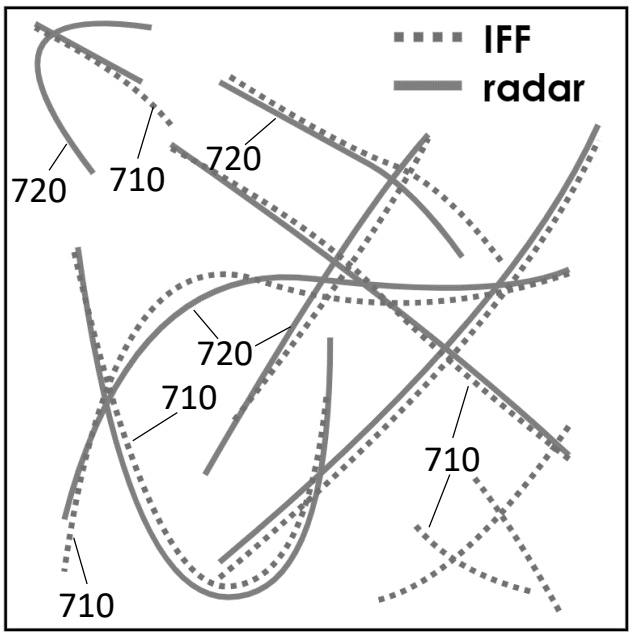
IFF
radar
720
710
720
720
710
710
710

FIG.7A

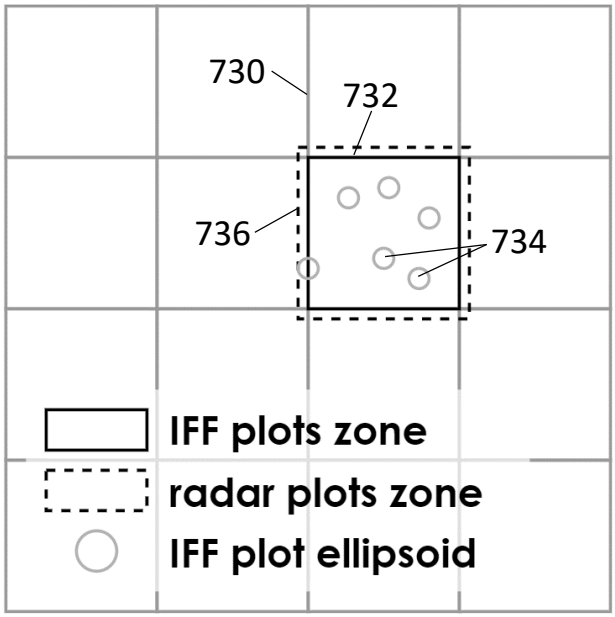
730
732
736
734
IFF plots zone
radar plots zone
IFF plot ellipsoid

FIG.7B

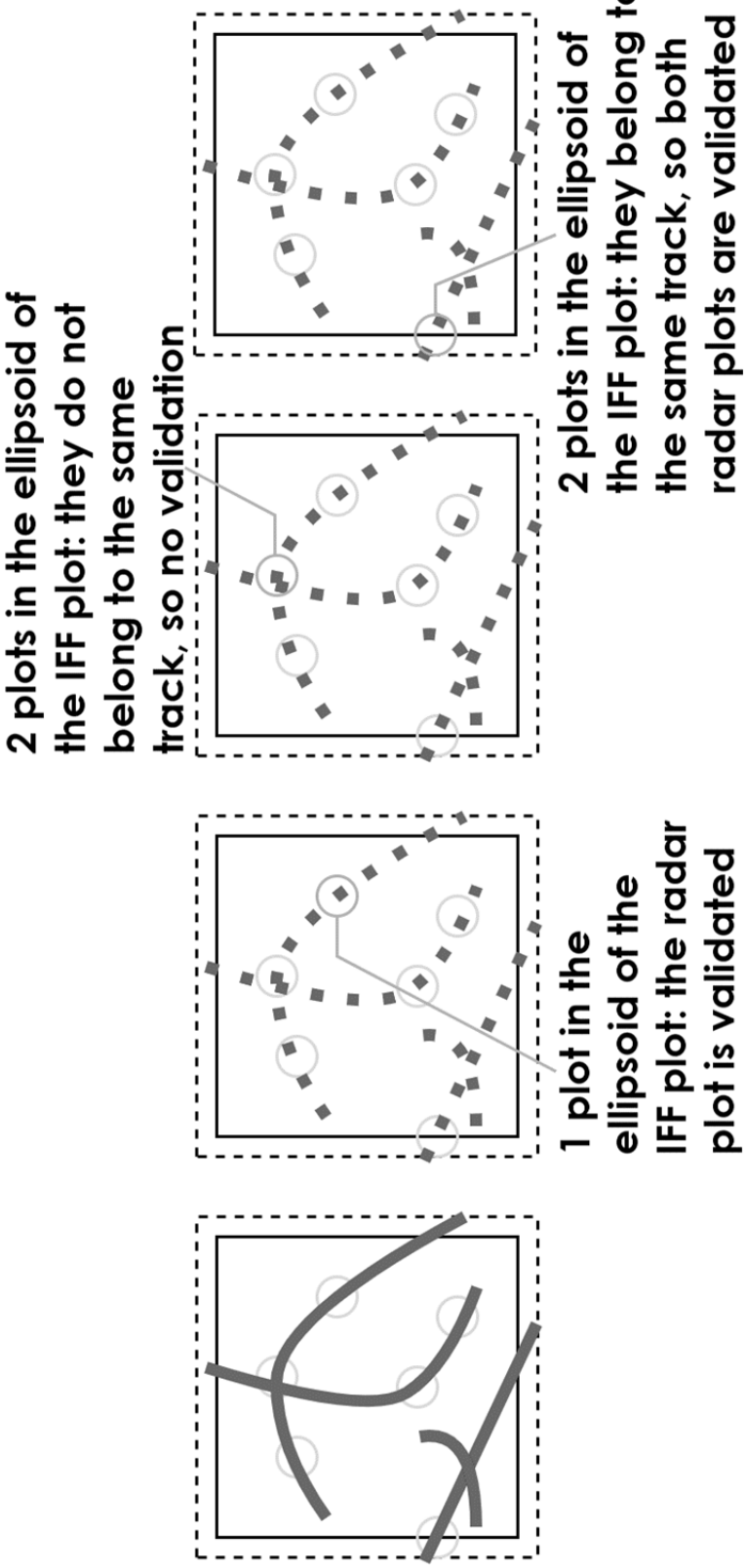
2 plots in the ellipsoid of the IFF plot: they do not belong to the same track, so no validation
1 plot in the ellipsoid of the IFF plot: the radar plot is validated
2 plots in the ellipsoid of the IFF plot: they belong to the same track, so both radar plots are validated

FIG.7C

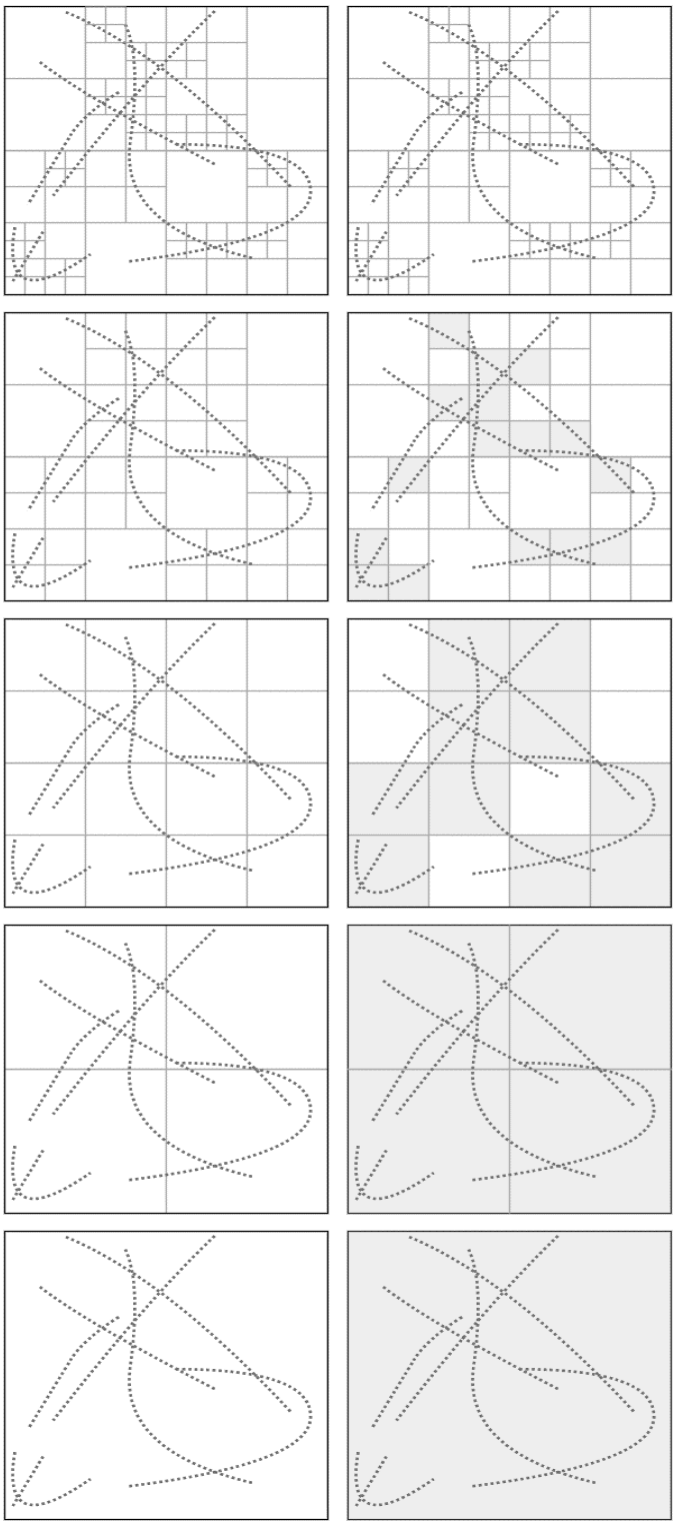

FIG.7D

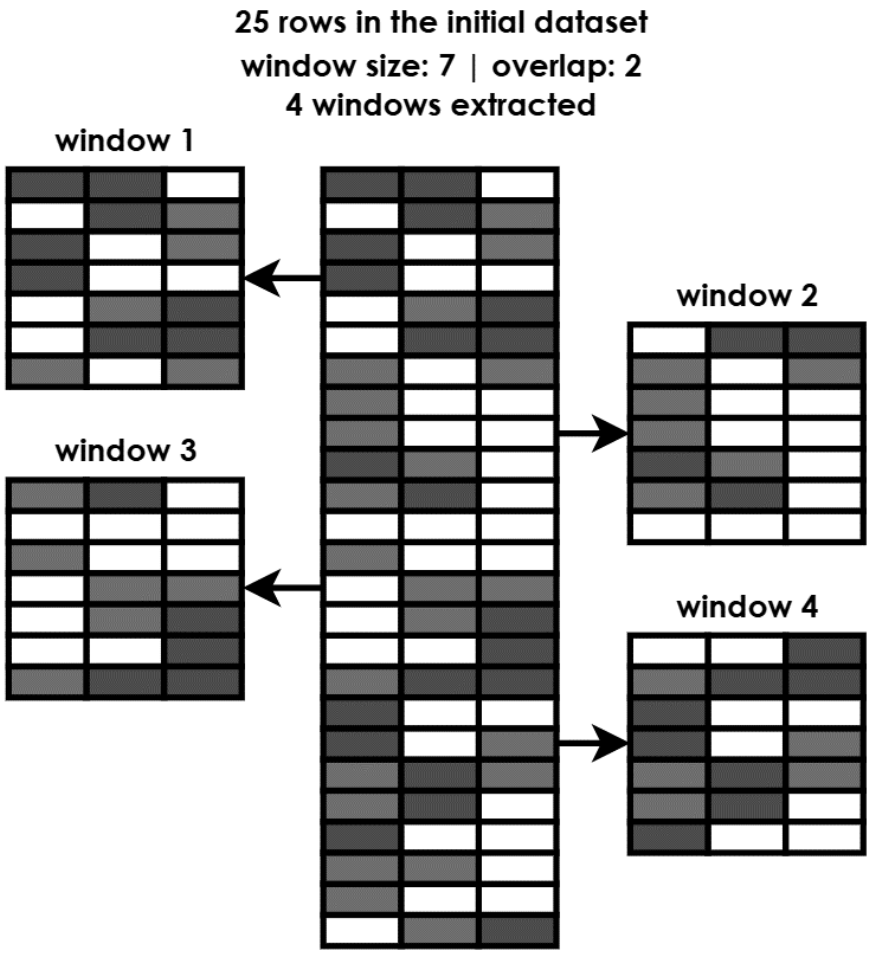
25 rows in the initial dataset
window size: 7 | overlap: 2
4 windows extracted
window 1
window 2
window 3
window 4

FIG.8

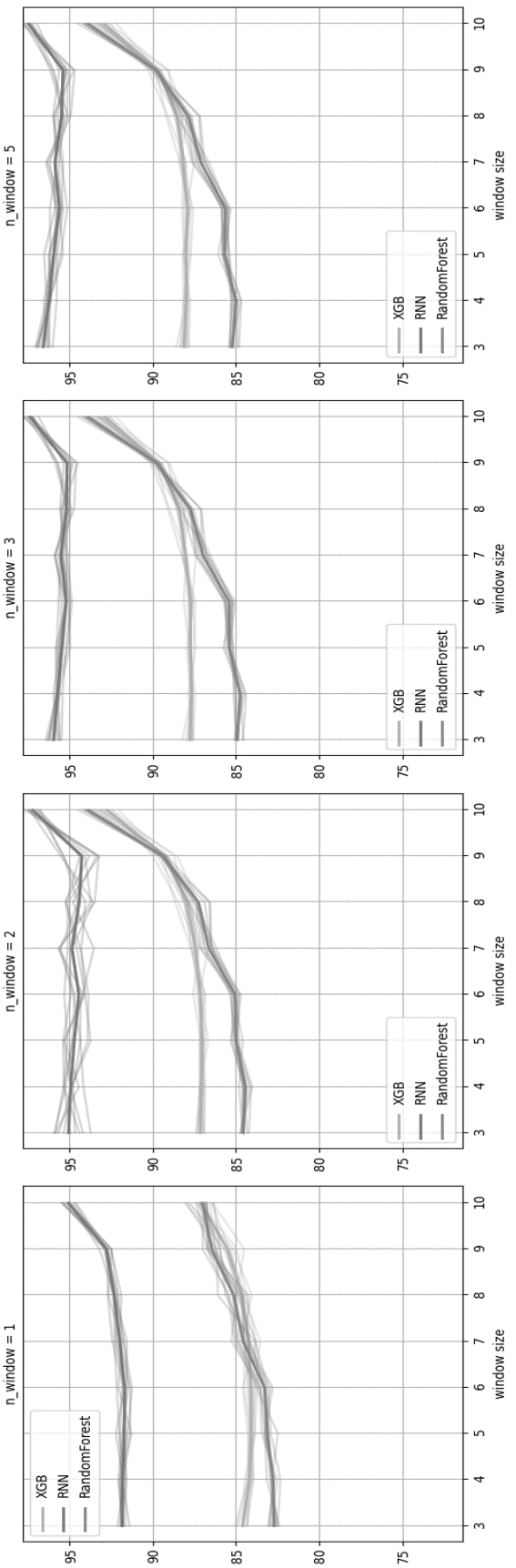
n_window = 1
n_window = 2
n_window = 3
n_window = 5
XGB
RNN
RandomForest
window size
95
90
85
80
75
3
4
5
6
7
8
9
10

FIG.9

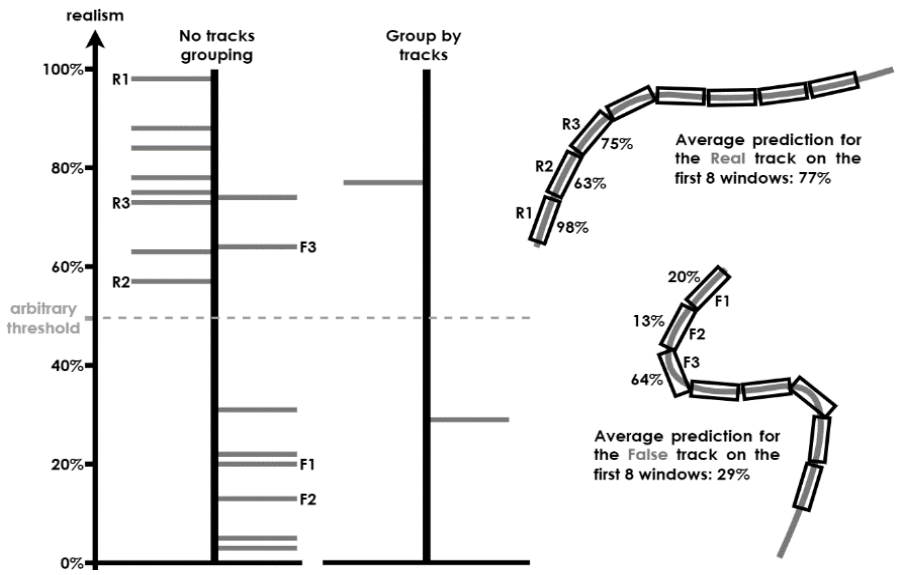
realism
No tracks grouping
Group by tracks
100%
80%
60%
40%
20%
0%
R1
R2
R3
F1
F2
F3
arbitrary threshold
R3
75%
R2
63%
R1
98%
Average prediction for the Real track on the first 8 windows: 77%
20%
F1
13%
F2
F3
64%
Average prediction for the False track on the first 8 windows: 29%

FIG.10

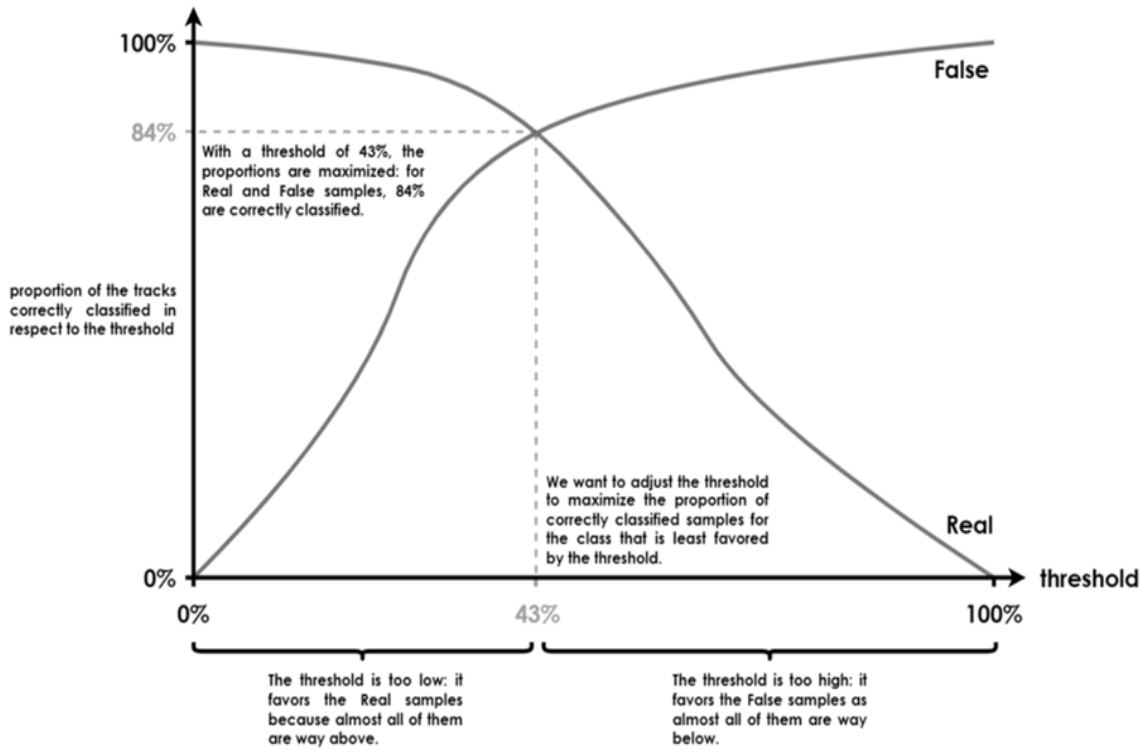
100%
84%
False
With a threshold of 43%, the proportions are maximized: for Real and False samples, 84% are correctly classified.
proportion of the tracks correctly classified in respect to the threshold
We want to adjust the threshold to maximize the proportion of correctly classified samples for the class that is least favored by the threshold.
Real
0%
threshold
0%
43%
100%
The threshold is too low: it favors the Real samples because almost all of them are way above.
The threshold is too high: it favors the False samples as almost all of them are way below.

FIG.11

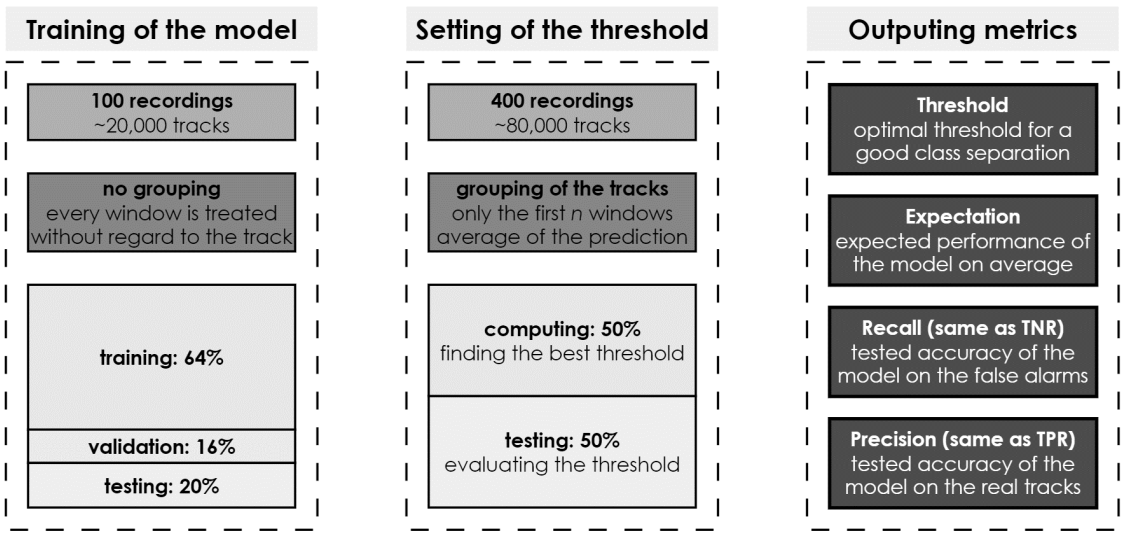
Training of the model
100 recordings
~20,000 tracks
no grouping
every window is treated without regard to the track
training: 64%
validation: 16%
testing: 20%
Setting of the threshold
400 recordings
~80,000 tracks
grouping of the tracks
only the first n windows average of the prediction
computing: 50%
finding the best threshold
testing: 50%
evaluating the threshold
Outputing metrics
Threshold
optimal threshold for a good class separation
Expectation
expected performance of the model on average
Recall (same as TNR)
tested accuracy of the model on the false alarms
Precision (same as TPR)
tested accuracy of the model on the real tracks

FIG.12

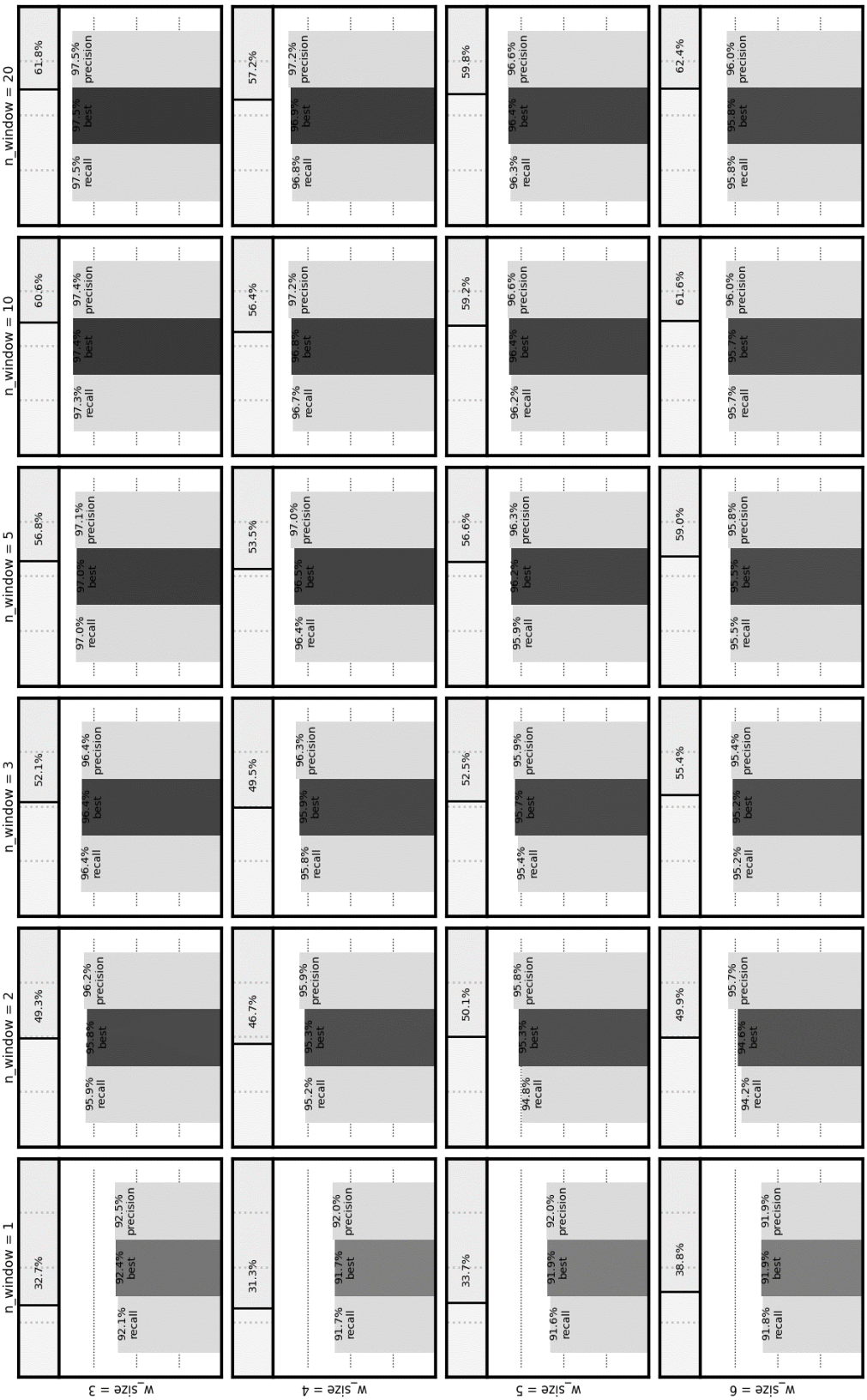
n_window = 1
n_window = 2
n_window = 3
n_window = 5
n_window = 10
n_window = 20
w_size = 3
w_size = 4
w_size = 5
w_size = 6
32.7%
49.3%
52.1%
56.8%
60.6%
61.8%
92.1% recall
92.4% best
92.5% precision
95.9% recall
96.0% best
96.2% precision
96.4% recall
96.4% best
96.4% precision
97.0% recall
97.0% best
97.1% precision
97.3% recall
97.4% best
97.4% precision
97.5% recall
97.5% best
97.5% precision
31.3%
46.7%
49.5%
53.5%
56.4%
57.2%
91.7% recall
91.7% best
92.0% precision
95.2% recall
95.3% best
95.9% precision
95.8% recall
95.9% best
96.3% precision
96.4% recall
96.5% best
97.0% precision
96.7% recall
96.8% best
97.2% precision
96.8% recall
96.8% best
97.2% precision
33.7%
50.1%
52.5%
56.6%
59.2%
59.8%
91.6% recall
91.9% best
92.0% precision
94.8% recall
95.3% best
95.8% precision
95.4% recall
95.7% best
95.9% precision
95.9% recall
96.2% best
96.3% precision
96.2% recall
96.4% best
96.6% precision
96.3% recall
96.4% best
96.6% precision
38.8%
49.9%
55.4%
59.0%
61.6%
62.4%
91.8% recall
91.9% best
91.9% precision
94.2% recall
94.6% best
95.7% precision
95.2% recall
95.2% best
95.4% precision
95.5% recall
95.5% best
95.8% precision
95.7% recall
95.7% best
96.0% precision
95.8% recall
95.8% best
96.0% precision

FIG.13