Improving ICU Alarm Systems with Machine Learning: A Case Study

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Some facts

Each day, a large number of individuals rely on ICU for their survival.

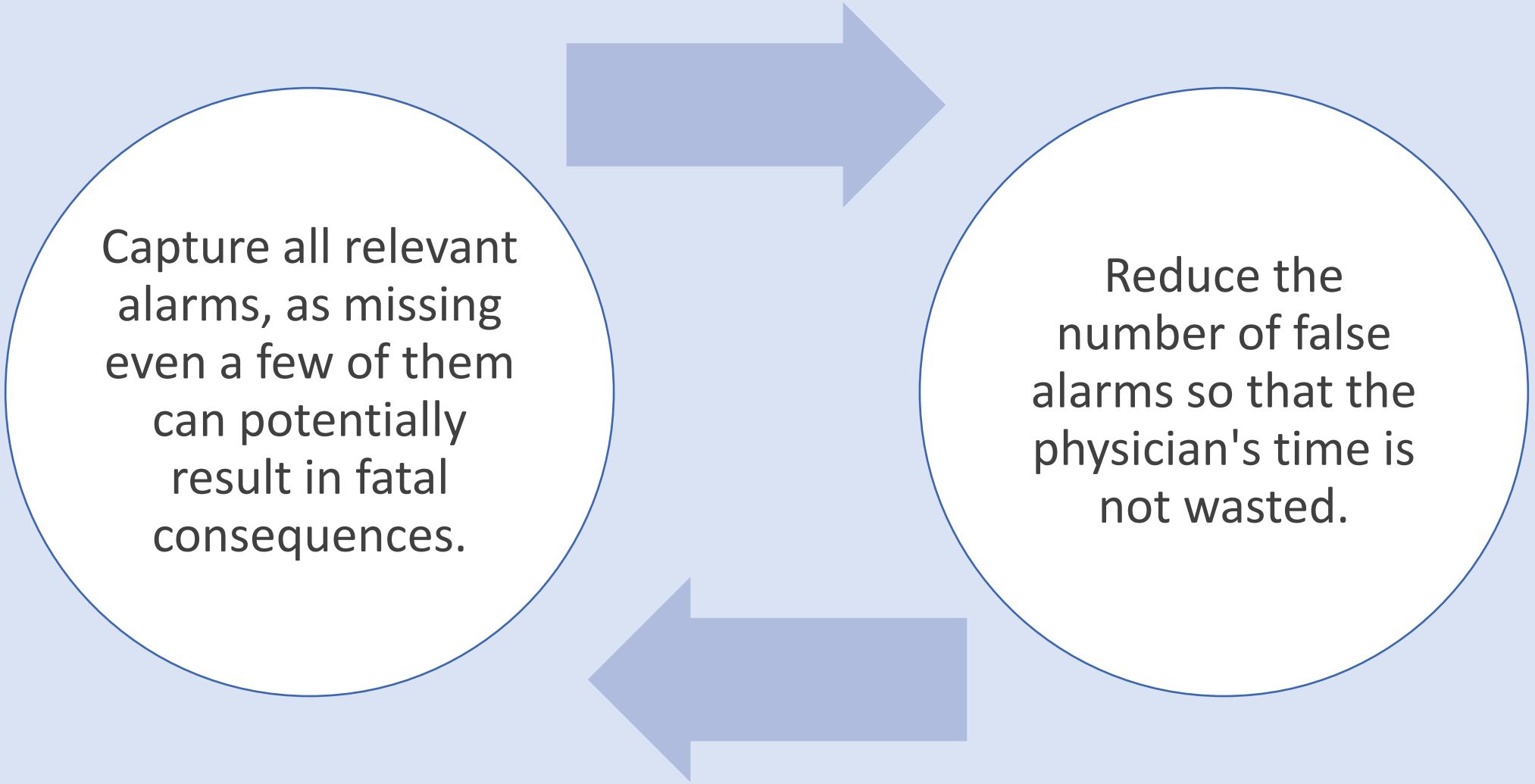
Alarms on ICU devices are sensitive and triggered easily.

False alarms require 2 minutes of a physician's time while relevant alarms need 5 minutes to be addressed.

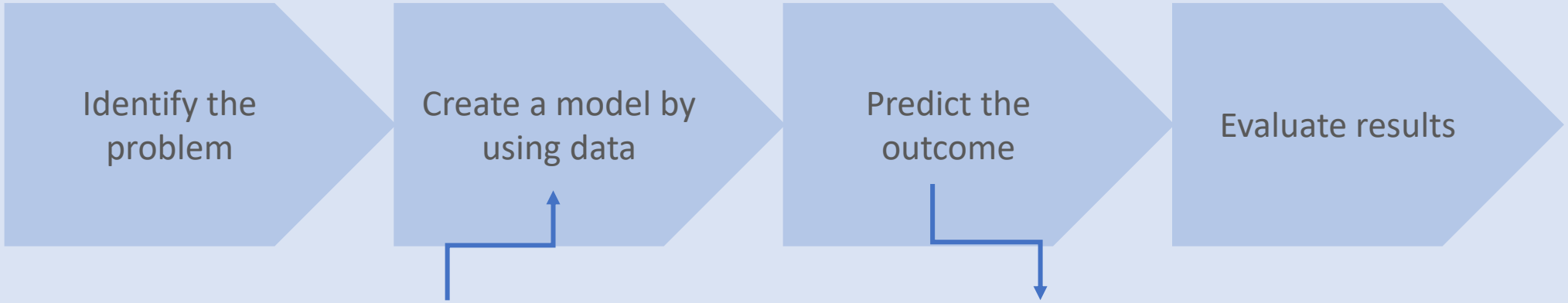
For each patient, 100 alarms are produced. Only 29 of them are relevant.

Three relevant alarms would still be missing among them.

Objectives


Capture all relevant alarms, as missing even a few of them can potentially result in fatal consequences.
Reduce the number of false alarms so that the physician's time is not wasted.

How to use ML for this specific case?



	hr	rr	spo2	sys	dia	monitor_alarm	doctor_alarm
0	94	15	100	163	81	False	False
1	88	15	99	128	62	False	False
2	82	17	100	103	50	False	False
3	89	18	100	139	83	False	False
4	95	26	100	153	73	False	False
...	...	..	...	...	...	...	...
3823	117	30	99	113	44	True	False
3824	120	30	99	97	45	True	True
3825	119	18	99	100	46	True	False
3826	117	28	94	103	49	True	True
3827	111	26	97	107	47	False	True

monitor_alarm
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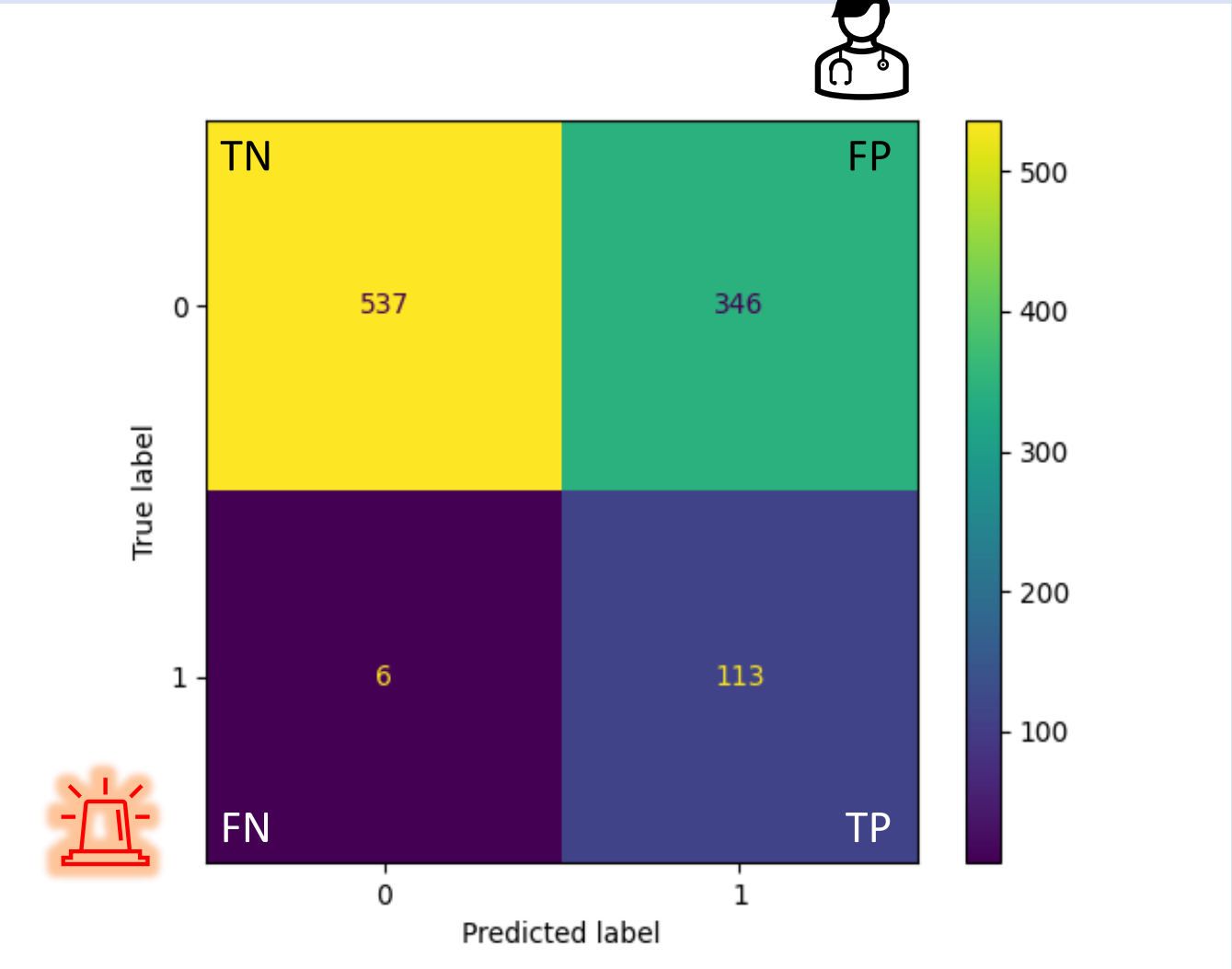
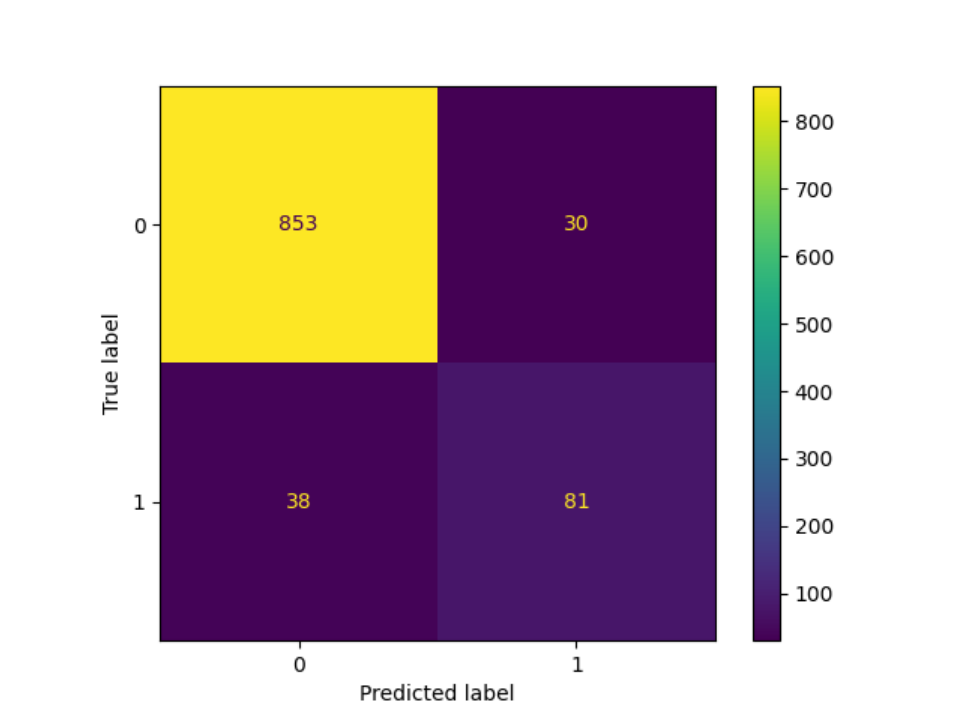
Alarm detection with the default system



Accuracy rate: 0.648

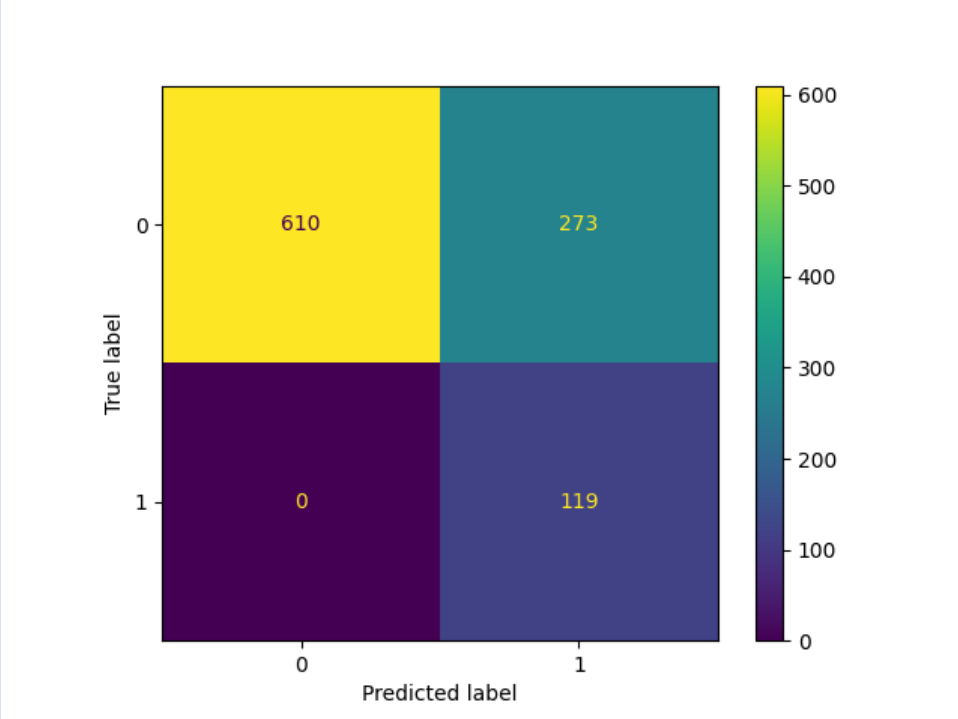
Alarm detection with the trained model

When prioritizing the minimization of false alarms:



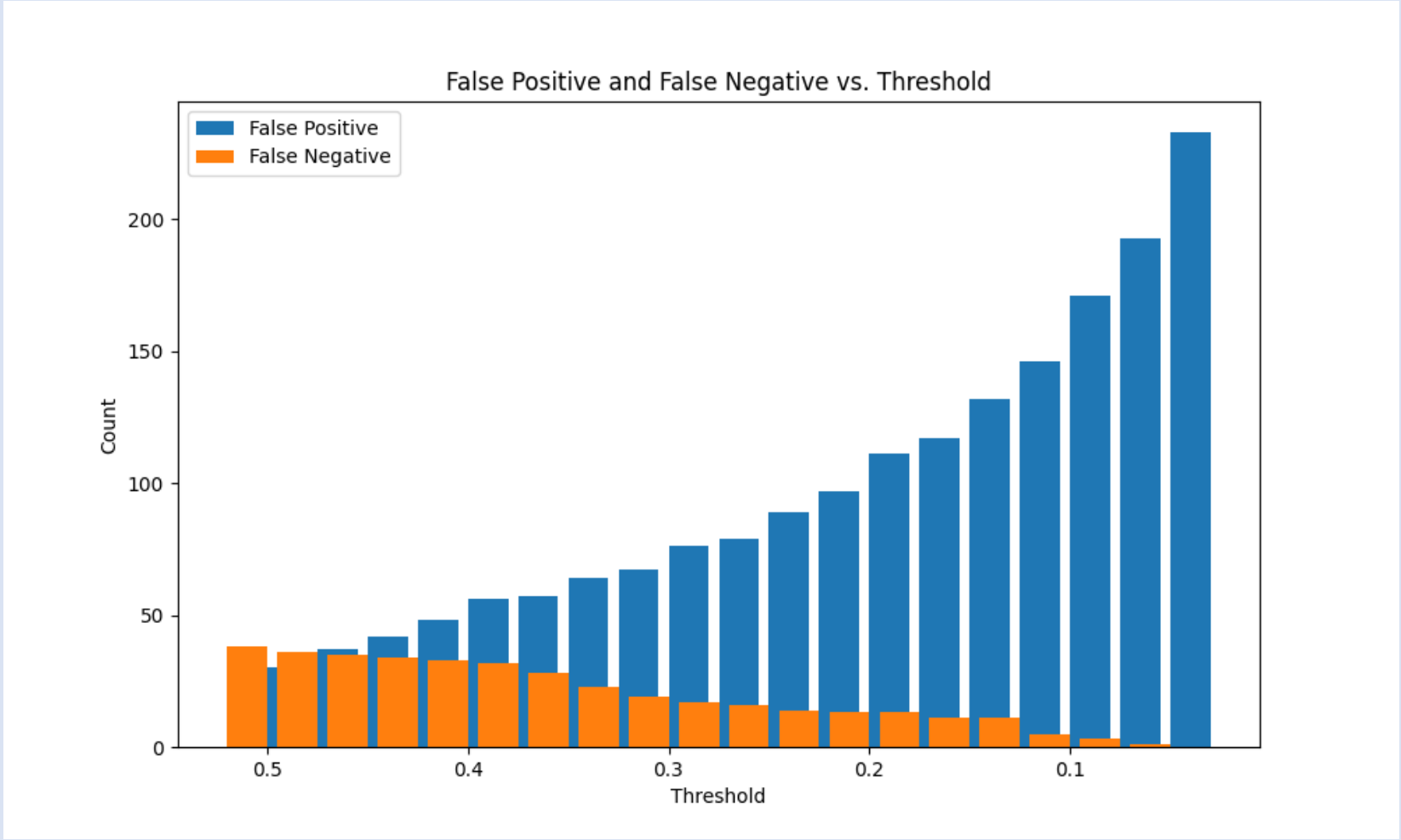
Accuracy rate: 0.932

When prioritizing the detection of all correct alarms:

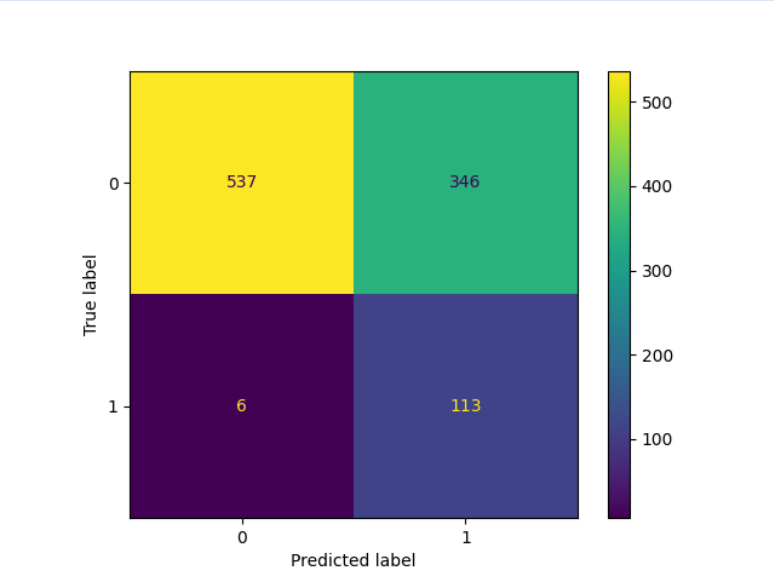


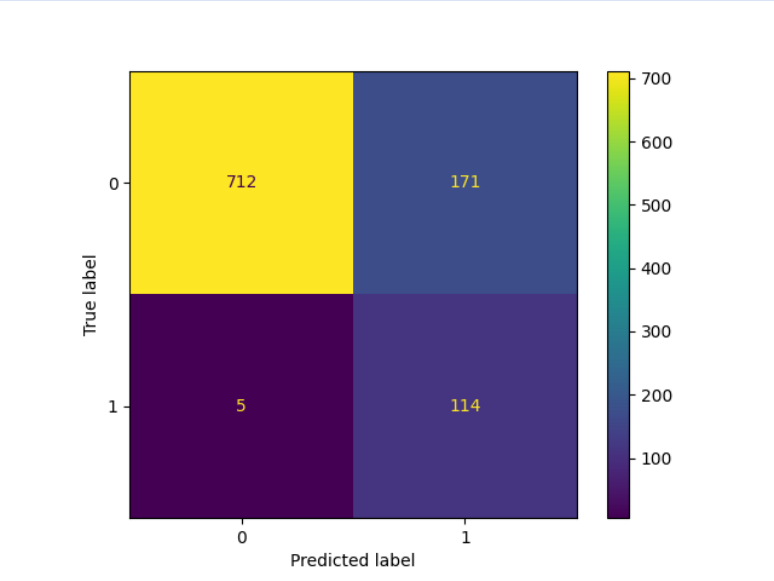
Accuracy rate: 0.727

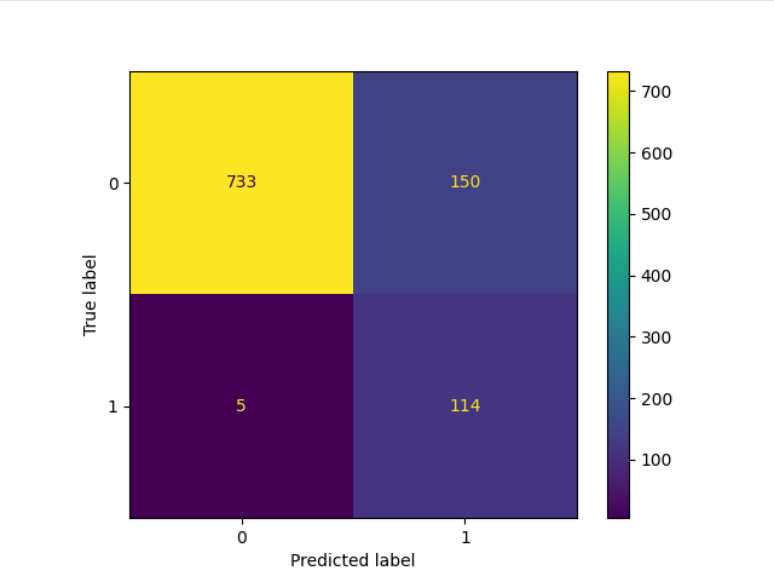
The trade-off between incorrectly identified false alarms and undetected true alarms



Comparison of 1000 alarms





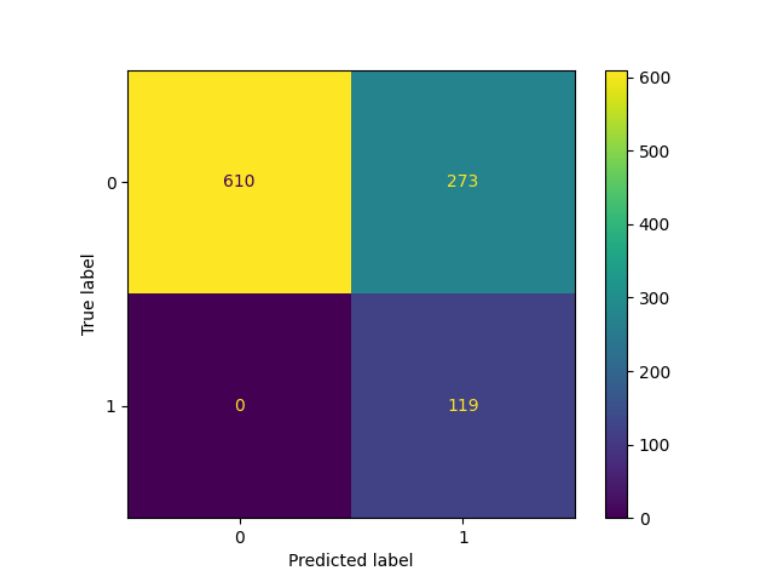


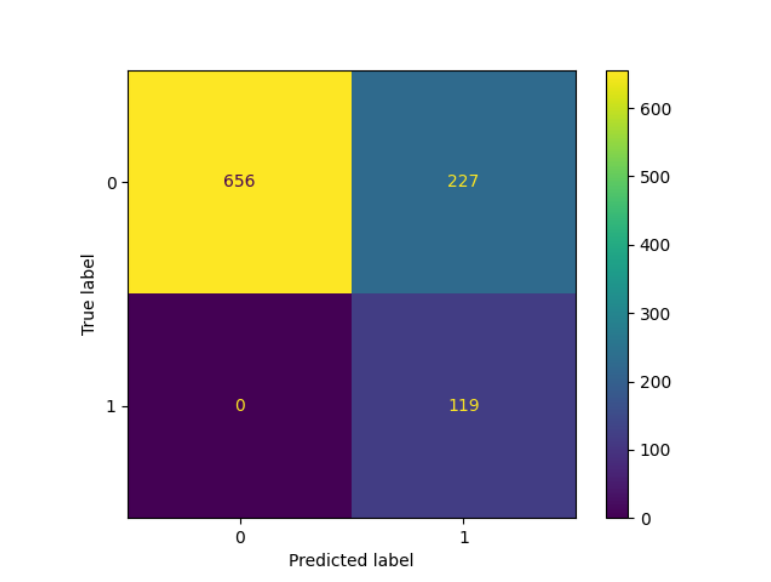
Default model:
34.5% of alarms are FP (1 hour 15 minutes)

Initial ML model:
17.1% of alarms are FP (35 minutes)

Optimized ML model:
15% of alarms are FP (30 minutes)

Optimized results





Initial ML model:

27.3% of alarms are FP (55 minutes)

Optimized model:

22.7% of alarms are FP (45 minutes)