Echodyne® EchoGuard Multi-class Classifier (SW 18.1)

Introduction

The Echodyne® EchoGuard Multiclass Classifier helps figure out what kind of object a track might be. It considers factors such as the object's speed, size, and location. As new data is received, the system predicts the object type with probabilities and aggregates them to improve accuracy over time. These probabilities are included in the track data, and by default, Echodyne reports the type with the highest probability.

Purpose

The release of EchoGuard software 18.1 includes an updated Multiclass Classifier that significantly improves classification performance. This release replaces the earlier decision tree model in SW 17.0 with a more sophisticated Random Forest model, yielding improved accuracy in classifying objects, with notable gains in Unmanned Aerial Vehicle (UAV) recognition.

The Random Forest model is a type of ensemble learning, which means it combines the results of many decision trees to make better, more accurate predictions. Instead of relying on just one decision tree—which might make mistakes or focus too much on the training data—the model uses a whole "forest" of trees. Each tree asks a series of questions and makes its own decision. Then, the forest takes a vote across all trees to choose the most reliable answer. This approach improves accuracy and reduces overfitting (when a model learns the training data too well and performs poorly on new data).

The name "Random Forest" reflects this concept—just like a rainforest is full of different trees and plants, this model builds strength from data diversity and numbers.

As the random forest model learns, its accuracy grows.

Metrics

Three core metrics were used to evaluate improvements and measure performance gains:

IMPORTANT! Note that any two of the three metrics provided fully defines the classifier's performance.

- **True Positive Rate (Recall)**: If the target is a UAV, how likely is the radar to correctly identify it as such?

  Example: A radar registers 10 UAV events, 6 of them are classified as UAVs and 4 are classified as birds. The true positive rate (recall) is 60%.

- **Precision**: Out of all the times the object was classified as a UAV, how many times was EchoGuard correct?

  Example: An EchoGuard radar registers 10 UAV alerts – 6 are UAVs and 4 are false positives. How precise is the radar? In this case, it would be 60% precise.

- **False Alarm Rate (FAR)**: How likely is the radar to mistake a non-UAV object for a UAV?

  Example: A large bird might briefly be tagged as a UAV if it's flying like one. Once the radar gathers more data on its speed and movement, it corrects the label to "bird."

The following graphic breaks down what the radar sees and how each metric evaluates the objects.

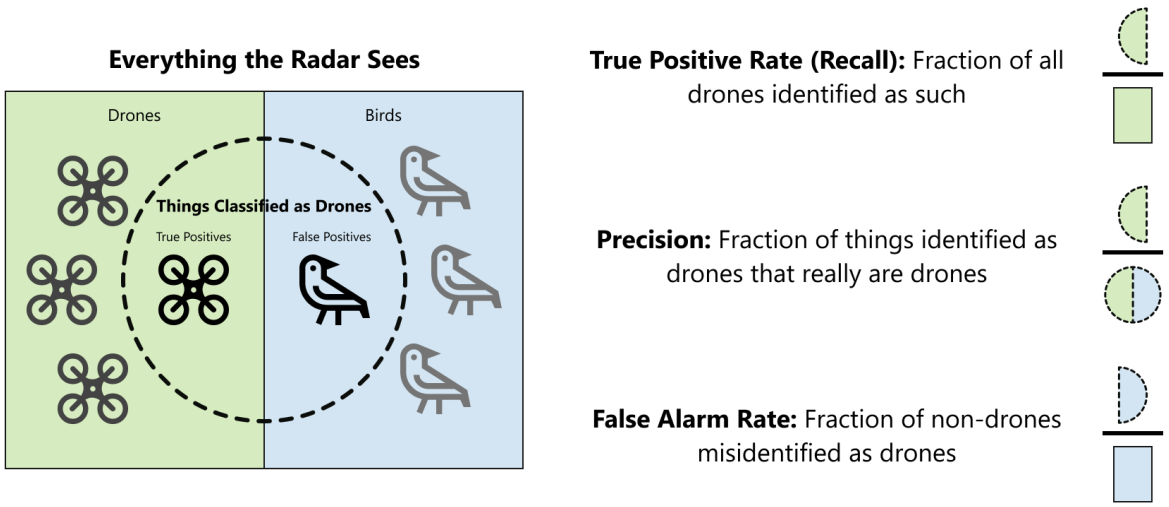

Figure 1: Core metrics explained

Performance

SW 18.1 consistently delivered strong improvements across multiple testing environments, with particularly significant gains in UAV classification. Figure 1 explains what the radar sees and how things are classified as drones — but what's the difference between precision and recall, and how does it affect the data captured?

Precision versus Recall

Understanding the difference between precision and recall can be tricky. Think of precision as how often the radar "is right" when it's found something—high precision means few false alarms. Recall is how often a radar catches the real objects that are actually out there—high recall means it rarely misses anything. In real life, you can't always maximize both precision and recall: if the radar catches every possible target (high recall), the radar could also pick up more clutter or harmless objects (lower precision). If the radar avoids false alarms (high precision), you risk missing some real targets (lower recall).

Both precision and recall describe different aspects of radar performance. They're connected, but not opposites. Precision shows how reliable the radar's detections are — of all the objects it declares as targets, how many are correct. Recall (or probability of detection) shows how many real targets the radar actually finds.

To recap, precision is how reliable the radar's detections are, while recall is how often it correctly identifies real objects. They affect each other but are not exact opposites.

False Alarm Rate

The false alarm rate measures how often radar classifies non-targets—like birds, clutter, or weather—as real targets such as drones. Too many false alarms can flood operators with false targets, making it harder to focus on real threats. Because false alarms depend on the environment and object classification, the improved Echodyne® EchoGuard Multiclass Classifier enables the radar to more accurately distinguish drones from birds, clutter, and weather—sharpening detection, reducing false alarms, and strengthening overall system performance in complex conditions.

False Alarm Rate versus Precision

Both false alarm rate and precision measure *different* aspects of radar performance, though they are linked:

- Lowering false alarms generally increases precision.
- Reducing false alarms often comes at the cost of decreasing recall, causing more “true” targets to be missed.
- Precision is about the quality of declared detections, while the false alarm rate measures how often non-targets are incorrectly reported as targets.

Operational Notes

The SW 18.1 classifier supports both **binary** (UAV versus other) and **multiclass** classification modes, giving you the flexibility to tailor radar performance to specific missions or operational scenarios. In either mode, the classifier outputs a probability distribution across all defined classes, with the probabilities summing to 1—ensuring a consistent and interpretable confidence measure for each detection.

NOTE: The Command and Control Center (C2) can convert the classifier to binary mode (UAV versus Other) by aggregating the remaining six classes.

Conclusion

With the multiclass classifier, Echodyne aims to strike the right balance between minimizing false alarms and maintaining strong recall. It’s important to note that no classifier will ever reduce false alarms to zero, and the observed false alarm rate may vary depending on the environment where the radar is deployed.

With the release of the updated multiclass classifier, you should expect to see significantly improved classification performance. While overall accuracy has increased, it’s important to keep in mind that no system can fully eliminate false alarms, and results may still vary depending on the specific deployment environment.

Support

If you have further questions, please contact: support@echodyne.com