SPECTRO AI

Thermal Bird Nest Detection

Performance & Operating Guide

PREPARED BY	Spectro-AI	SUBJECT	Thermal Bird Nest detection algorithm
RUNS ON	DJI Matrice 4T / 4TD (on-board)	MORE INFO	spectroai.ai
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OPERATIONAL SAFETY The algorithm is an operator-assistance tool and does not replace the pilot's responsibility to maintain safe flight or comply with applicable aviation regulations. All detections should be verified before operational decisions are made.

INTENDED USE This algorithm is designed to assist operators in locating Bird Nests during aerial thermal surveys. It can highlight areas requiring further investigation, but should not be used as a replacement for manual verification, species identification or any form of ecological assessment.

WILDLIFE DISTURBANCE Breeding birds and their Bird Nests are legally protected in many jurisdictions, and surveying them may require a licence or permission. Operators are responsible for establishing and meeting those obligations. Fly no lower and no longer than the survey requires, keep passes brief, and immediately increase altitude or terminate the survey if birds show signs of disturbance. Flying low over an active Bird Nest can drive the adult off, which harms the birds and removes the very heat signature the algorithm depends on.

1 About this guide

This guide explains how the Spectro-AI thermal Bird Nest detection algorithm performs when running on-board DJI Matrice 4 Series thermal aircraft, and how to fly and configure the payload to obtain the most reliable results.

The algorithm runs directly on the aircraft and reports detections in real time during the flight through the DJI Pilot 2 application. It detects a single class, Bird Nest, from White Hot thermal imagery. It is intended for ecological survey work: locating and mapping Bird Nests during the breeding season, and reducing the time spent searching ground by foot.

Performance figures presented in this guide were established under validated operating conditions and should be used as operational guidance rather than guaranteed performance. Detection accuracy varies with thermal contrast, vegetation, weather, flight height, gimbal angle and image stability.

2 Supported aircraft

The algorithm is trained on thermal imagery. It requires a thermal camera and therefore runs only on the thermal variants of the Matrice 4 Series.

Table 2.1 *Aircraft compatibility*

Aircraft	Status	Reason
DJI Matrice 4T	**Supported**	Thermal camera fitted
DJI Matrice 4TD	**Supported**	Thermal camera fitted (dock variant)
DJI Matrice 4E	**Not supported**	No thermal camera. Visual payload only.
DJI Matrice 4D	**Not supported**	No thermal camera. Visual payload only.

THERMAL PAYLOAD REQUIRED The Matrice 4E and Matrice 4D carry visual cameras only (RGB) and cannot run this algorithm. Use a Matrice 4T or Matrice 4TD.

3 What the algorithm recognises

The algorithm detects a single class, Bird Nest, and displays each detection as a bounding box with an associated confidence score on the live thermal image in DJI Pilot 2. It is designed to assist operators in locating Bird Nests and does not identify species.

The heat comes from the eggs, not the Bird Nest

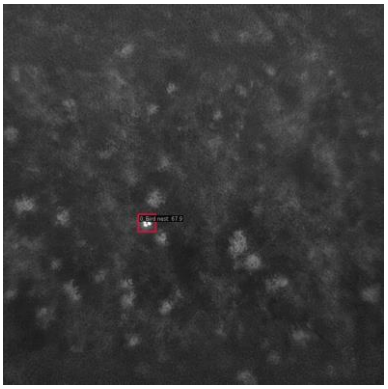
The algorithm keys on the warm thermal signature of eggs or a brooding adult, not on the structure of the Bird Nest itself. A Bird Nest is visible to the thermal camera because something warm is sitting in it. This single fact drives almost everything else in this guide: an unattended Bird Nest whose eggs have gone cold has little or no thermal signature and may not be detected at all, however clearly a human eye would see it in daylight.

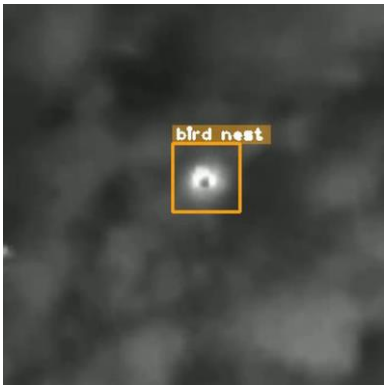
Both ground and elevated Bird Nests can be detected, provided the warm thermal signature is visible from above and can be distinguished from its surroundings. Detectability therefore depends less on where the Bird Nest is built than on the thermal contrast between its warm contents and the surrounding environment.

The algorithm can detect some partially visible thermal signatures, where part of the warm contents is exposed to the sensor. It cannot detect a Bird Nest fully hidden by vegetation or obstacles. A thermal camera does not see through leaves, branches or solid cover; it can only register heat that reaches the sensor directly.

IMPORTANT: DETECTIONS ARE NOT NEST COUNTS The algorithm identifies Bird Nest locations, not Bird Nest or breeding-pair numbers. Occupied Bird Nests close together may appear as a single detection, and any Bird Nest that is unoccupied, cold or hidden will not appear at all. Detection totals will generally understate what is present and must not be used as a census figure, a population estimate or a breeding-pair count without independent ground verification.

Table 3.1 *Example detections on White Hot thermal imagery*

Detection (with bounding box)	What it shows
	**Validation image, nadir view** The Bird Nest occupies a very small part of the frame: a compact bright core against cooler vegetation. The surrounding ground carries warm patches of its own, and it is the hotter, more concentrated core that separates the Bird Nest from that clutter.

Detection (with bounding box)	What it shows
	**In-flight detection** A Bird Nest boxed on the live thermal image during flight. This is what the operator sees in DJI Pilot 2: a box and a confidence score drawn around the warm signature as the aircraft passes over it.

4 Detection performance

Validation was performed on an independent dataset that was held out from training and evaluated separately. The results below describe how the algorithm performed under the tested conditions. They are estimates of expected performance, not a guarantee of field results.

0.901	0.493
mAP@0.50	mAP@0.50–0.95

What these numbers mean

The validation scores indicate how consistently the algorithm identified and located Bird Nests in the tested images. Higher scores indicate stronger performance under those conditions.

- **mAP@0.50 (0.901).** The measure of whether Bird Nests were found and placed in roughly the right position. The validation results indicate strong detection performance under the tested conditions. For most operators, this is the figure that reflects the question that matters: was the Bird Nest located?
- **mAP@0.50–0.95 (0.493).** A stricter measure that also rewards how tightly the box is drawn around the Bird Nest. The warm signature is often only a few pixels across, so a tight box is hard to draw. A lower figure here says little about whether the Bird Nest was found.

In plain terms: the algorithm was effective at locating warm Bird Nest signatures in the validated test conditions. These scores do not directly represent guaranteed field success. Actual performance depends on thermal contrast, whether the Bird Nest is occupied, vegetation, environment and operating conditions, and will vary from one flight to the next.

Precision and recall at a single fixed confidence threshold were not measured in this validation. Use the threshold guidance below as a starting point and tune it against your own site.

> **CONFIDENCE-THRESHOLD SLIDER** A confidence threshold around 0.40 is recommended as a starting point. Lower thresholds may improve sensitivity but will increase false alarms. Higher thresholds reduce false alarms but risk missing weaker signatures, which matters here because a Bird Nest signature is small to begin with. The recommended setting may vary depending on terrain, season, weather, and mission objectives, so expect to re-tune between sites and between sorties.

5 Operating recommendations

Thermal palette

WHITE HOT ONLY The algorithm is trained exclusively on the White Hot palette and must only be used with White Hot selected in DJI Pilot 2. Black Hot, Ironbow and all other palettes invert or recolour the thermal signature and are not supported. Detection performance on them is not validated and should not be relied upon.

Flight height and gimbal angle

Table 5.1 *Validated operating envelope*

Parameter	Validated setting	Notes
Flight height	**20 – 40 m above ground level (AGL)**	The full validated range, flown without zoom. Lower gives a larger, clearer signature; higher covers more ground and disturbs less.
Gimbal pitch	**−90° (nadir), ±5°**	The algorithm is trained on top-down imagery. Oblique views are not validated.
Thermal palette	**White Hot**	Mandatory. No other palette is supported.
Confidence threshold	**0.40 to start**	Adjustable in DJI Pilot 2. Tune to the site and conditions.

Choosing a flight height

Lower altitude improves thermal detail; higher altitude covers more ground and disturbs the birds less. The validated range is narrow, so the working rule is simple: start at the top of it, and descend only as far as detection actually requires. Height is the single biggest lever you have over disturbance, so treat the lowest usable height, not the lowest permitted height, as the target.

Table 5.2 *Suggested approach by survey scenario*

Survey scenario	Suggested approach
Starting a survey	Begin at the upper end of the range, approximately 40 m. If Bird Nests are being boxed reliably, stay there.
Signature too weak to detect	Descend in steps towards 20 m, and stop as soon as detection becomes reliable. Do not descend further than the signature requires.
Confirming a detection	Hold height and inspect the live image. Descend only if the detection cannot be resolved from where you are.
Dense or tall vegetation	Expect reduced detection. Working towards the lower end of the range may help, but a Bird Nest fully covered by vegetation cannot be detected at any height.
Birds showing disturbance	Increase altitude immediately or terminate the survey. This takes precedence over obtaining a detection.

> **HOW TO USE THIS** Set White Hot, point the gimbal straight down, and work within 20 to 40 m AGL. Begin at the upper end of the range. Descend in steps only while the thermal signature is too weak to detect, and stop as soon as it is not. Keep passes brief, and break off if the birds react.

Zoom (not validated for this algorithm)

The 20 to 40 m range above was validated without zoom, and no height-to-zoom pairing has been validated for this algorithm.

Optical zoom may still be useful. It increases the apparent size of the Bird Nest in the image, which in principle allows a higher, less intrusive flight height to be flown while keeping the signature large enough to detect. That is an attractive trade for a survey where disturbance matters. However, it is not a validated operating mode, and it should not be assumed to work: verify it against a Bird Nest whose position you already know before relying on it across a survey.

- **Treat any zoom setting as unproven until you have tested it.** Confirm on a known Bird Nest, in the prevailing conditions, on the day.
- **Do not use zoom to justify flying outside the validated height range.** The 20 to 40 m band is what has been tested.
- **Record what you used.** If zoom formed part of a survey, note the setting alongside the results so the two can be interpreted together.

> **OPTICAL ZOOM, NOT DIGITAL** If zoom is used, use optical zoom. Optical zoom changes the camera optics, so the Bird Nest genuinely occupies more pixels and the algorithm has more thermal detail to work with. Digital zoom simply crops and enlarges the existing image, adding no new thermal information. Digital zoom should not be relied upon to improve detection performance or extend detection range. Treat it only as a viewing aid for the operator after a detection has been made.

Thermal contrast and time of day

The algorithm can operate during both day and night, provided sufficient thermal contrast exists between the warm contents of the Bird Nest and the ground and vegetation around it. What matters is not light but heat.

- **Best conditions.** Cool ambient temperatures, cool ground and a clear sky. Typically at night, or in the early morning before the sun has warmed the vegetation. The eggs or brooding adult then stand out sharply against a cold background.
- **An unoccupied Bird Nest may be invisible.** If the adult has left and the eggs have cooled, there may be no thermal signature to find. Survey when Bird Nests are most likely to be occupied, and do not read an absence of detections as an absence of Bird Nests.
- **Hot days and warm nights.** Sun-heated ground raises the temperature of the surrounding vegetation towards that of the Bird Nest, and the contrast the algorithm relies on collapses. On a warm night the ground may not have cooled enough to recover it.
- **Thermal crossover periods.** Around dawn and dusk, ground and Bird Nest temperatures pass through each other and contrast can briefly disappear altogether.
- **Humidity, rain and fog.** Moisture in the air and on vegetation absorbs thermal energy and weakens the signature reaching the sensor.
- **Obstruction.** A Bird Nest concealed beneath dense canopy or overhanging vegetation may not be visible to the sensor at all, and cannot be detected by any algorithm.

Thermal lens cleanliness

Dirt, water droplets or condensation on the thermal lens reduce image contrast and may degrade detection performance. Inspect the lens before each flight and clean it as required, and allow time for condensation to clear when a cold aircraft is brought into warmer, more humid air.

6 Limitations

- **Thermal aircraft only.** The algorithm cannot run on the Matrice 4E or Matrice 4D.
- **White Hot only.** Any other palette places the algorithm outside its validated envelope.
- **Detection depends on a warm occupant.** The algorithm finds the heat of eggs or a brooding adult, not the Bird Nest itself. Cold or abandoned Bird Nests, and those imaged after the adult has been flushed, may not be detected.
- **No species identification.** Every detection is reported as Bird Nest. Species must be established by other means.
- **Small signatures.** Bird Nests typically occupy only a small part of the thermal image, particularly at higher flight altitudes. Precise localisation is more challenging than detecting that a Bird Nest is present.
- **Warm objects other than Bird Nests may be detected as Bird Nest.** Sun-warmed patches of ground, small mammals, rocks and birds away from Bird Nests can produce false positives, particularly at low confidence thresholds. Operators should always verify detections before acting.
- **Detections are not a census.** An absence of detections is not evidence of an absence of Bird Nests, and detection counts should not be treated as population or breeding-pair counts.
- **Nadir only.** Gimbal angles more than approximately 5° off nadir fall outside the validated envelope.
- **Zoom is not validated.** The operating envelope was established without zoom. Any use of zoom is outside the tested configuration and should be verified locally.
- **Performance figures are intended for operational planning and should not be interpreted as guaranteed performance under all conditions.**

Conditions where performance may decrease

The following are common situations in which detections become less reliable. Recognising them in the air is more useful than any single number.

- **Sun-warmed bare soil and exposed rock.** Both hold heat well after the sun has gone and can read as warm as an occupied Bird Nest, producing false positives.
- **Wet vegetation after rain.** Moisture absorbs thermal energy and masks the signature of a Bird Nest sitting in or beneath it.
- **An adult flushed off the Bird Nest.** Once the adult has left, the remaining signature is weaker and cools steadily. This is both a detection problem and a welfare one.
- **Dense canopy or overhanging vegetation.** A Bird Nest beneath closed cover is hidden from the sensor entirely and cannot be detected.
- **Warm afternoons.** Surrounding vegetation approaches the temperature of the Bird Nest contents and the contrast that makes detection possible is lost.

7 Deployment

The algorithm is licensed to the individual aircraft serial number and delivered through DJI Pilot 2. Once activated, it runs entirely on-board and does not require a network connection during operation.

> **VALIDATED VERSION** The validated performance described in this guide applies to the released algorithm version identified on the cover of this document, BirdNest-WhiteHot-SAI-V1. Later algorithm updates, aircraft firmware changes and different camera configurations may perform differently, and the figures here should not be assumed to carry over to them. Check the algorithm version shown in DJI Pilot 2 against the cover of this guide, and record it alongside any results you keep.

Questions, or results in conditions not covered here? Visit spectroai.ai.