Optic flow and energy invariants combined may explain gulls’ altitude profiles during offshore takeoff

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Aim: To investigate which cues are used by Gulls to control their altitude during takeoff by testing the constant optic flow hypothesis.

GPS tracking of Gulls

“Preferred ventral optic flow” Hypothesis

- When gulls are flying forward, the image of the sea sweeps backward across their ventral viewfield and forms an “optic flow”, which depends on both the groundspeed and the groundheight.
- The “ventral optic flow” perceived by the gull, i.e., the apparent angular velocity \( \omega \) created by a point directly below on the flight track, is simply equal to the ratio \( V_x/h \), between groundspeed, \( V_x \) and the groundheight, \( h \).

Are gulls controlling their altitude by keeping this ratio constant? (as flying insects are doing, Franceschini, Serres, Ruffier, 2007)

Results: Altitude Control Model parameterized using individual bird metrics (mass, wingspan, ...)

- We used high time resolution (10-15sec) GPS tracking of lesser black backed gull from off-shore takeoff towards their breeding colony.
- The altitude control model is based on (i) the bird elevation dynamics and (ii) the “constant optic flow” hypothesis using individual bird metrics.

\[
\begin{align*}
T_{GPS} &\approx 15 \text{s or 10s} \\
\omega_p &\approx 23 \pm 10^\circ/\text{sec} \\
V_{\text{max}} &\text{ from 0.2 to 0.45 m/sec}
\end{align*}
\]

Conclusion

- A linear 1st order parametric model on gulls’ data (18 trajectories) gives a fit factor value of 37.6% on average (range: 10 – 80%).
- By introducing a ceiling in the climbing rate according to Hedenström et al., 2003, In: Avian Migration (prediction 10), the non-linear parametric model on 18 trajectories gives a fit factor value of 57.1% on average (range 15 – 80%).
- For GPS-tracked offshore takeoffs by gulls, the normalized altitude computed with the mathematical model using GPS derived horizontal groundspeed data predicts altitudes close to actual GPS recorded altitude, thus suggesting gulls use an optic flow-based system for control of takeoff flight.