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▶ To cite this version:

Julien Serres, Aimie Berger Dauxère, Gilles Montagne. Honeybees' altitude control relies on same optical invariants as pilots. 53ème Colloque de la Société Française pour l'Etude du Comportement Animal (SFECA), May 2024, Albi, France. , 37, 2024. hal-04585486

HAL Id: hal-04585486

https://hal.science/hal-04585486

Submitted on 23 May 2024

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Honeybees' altitude control relies on same optical invariants as pilots*

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Main question: Perceiving a complex visual environment, what optical invariant does Apis mellifera focus on to stabilize its altitude?



Bases and aims

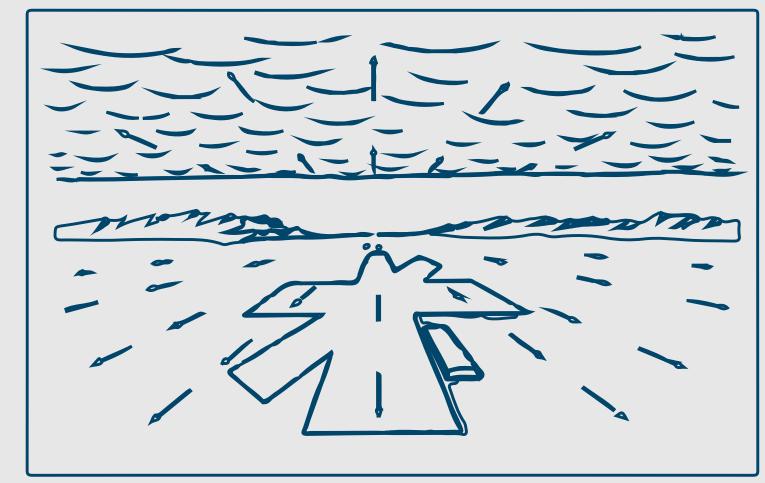
Optic flow: vector field of the apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an agent and the scene.

Optical invariants: particular properties of the optic flow unaltered when the agent is moving.

- Two optical invariants are particularily relevant for a ground_following task:
- optical speed rate of change $\dot{\omega}$ [used by bees and pilots]
- splay angle rate of change s [used by pilots]

(1) To determine if bees also use splay angle rate of change for performing ground-following tasks Aims:

(2) To set the priority and weight system by which bees use these two optical invariants to control their altitude



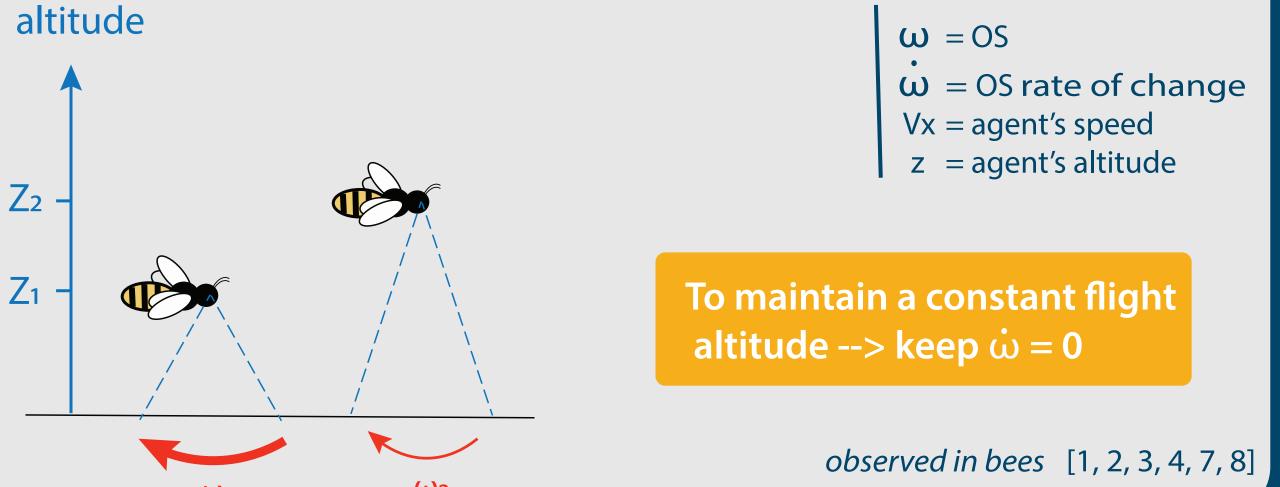
Optic flow field perceived by a flying agent (Gibson 1950, 1979)



Optical speed (OS) experienced by a flying agent

OS (ω) is the speed of environment's image scrolling the retina when an agent is moving.

- OS increases for an agent going down ($\dot{\omega} > 0$)
- OS decreases for an agent going up ($\dot{\omega}$ < 0)
- --> optical speed rate of change ($\dot{\omega}$) is informative about altitude change



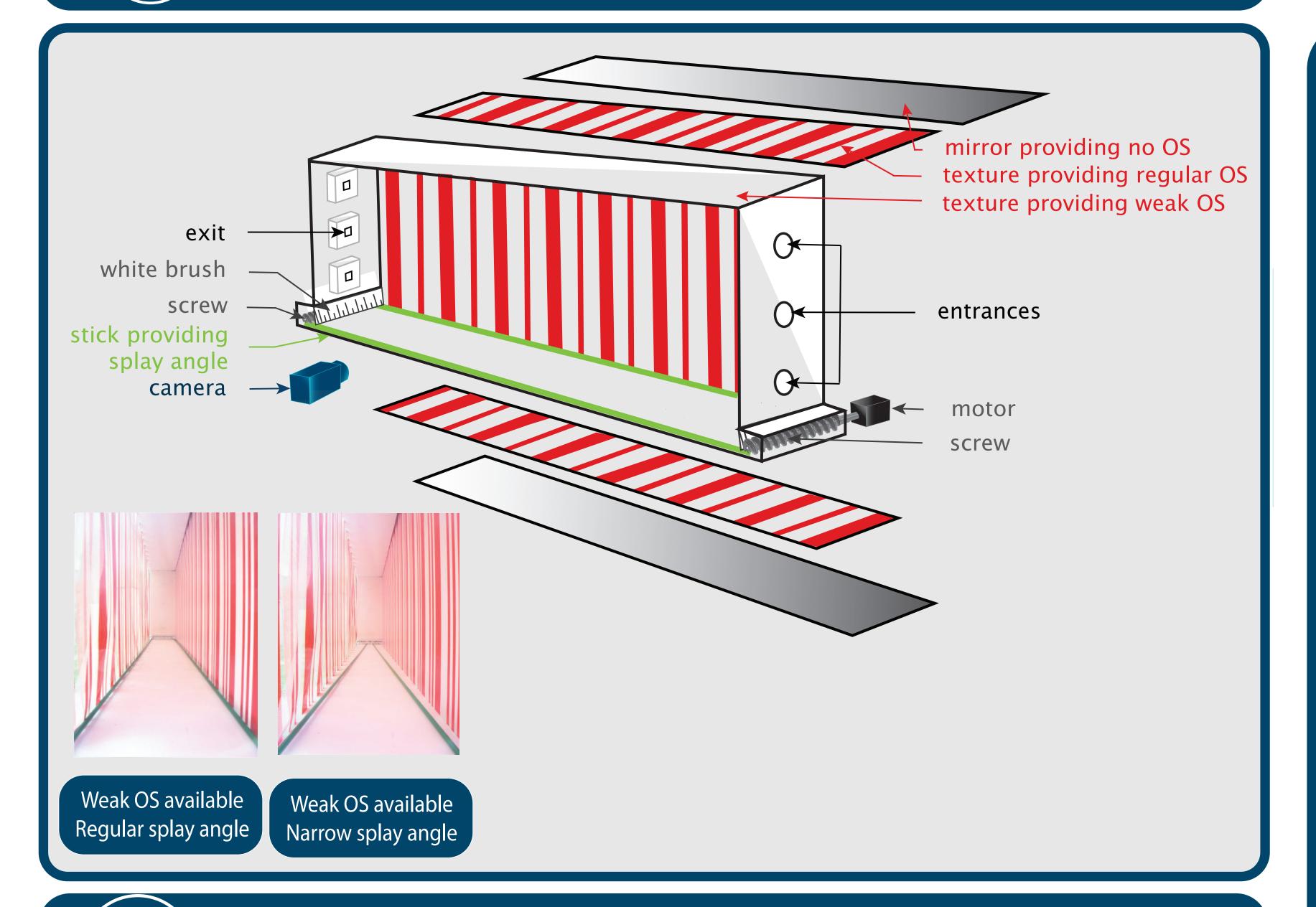
Splay angle rate of change experienced by a flying agent

Base lines join at the image's focus of expansion forming the splay angle (s): • angle's value increases in the visual field of an agent going down ($\dot{s} > 0$) • angle's value decreases in the visual field of an agent going up ($\dot{s} < 0$) altitude --> splay angle rate of change (s) is informative about altitude change Z_2 Z_1 horizon base line s = 1/2 angle formed by base lines

> To maintain a constant flight altitude --> keep $\dot{s} = 0$



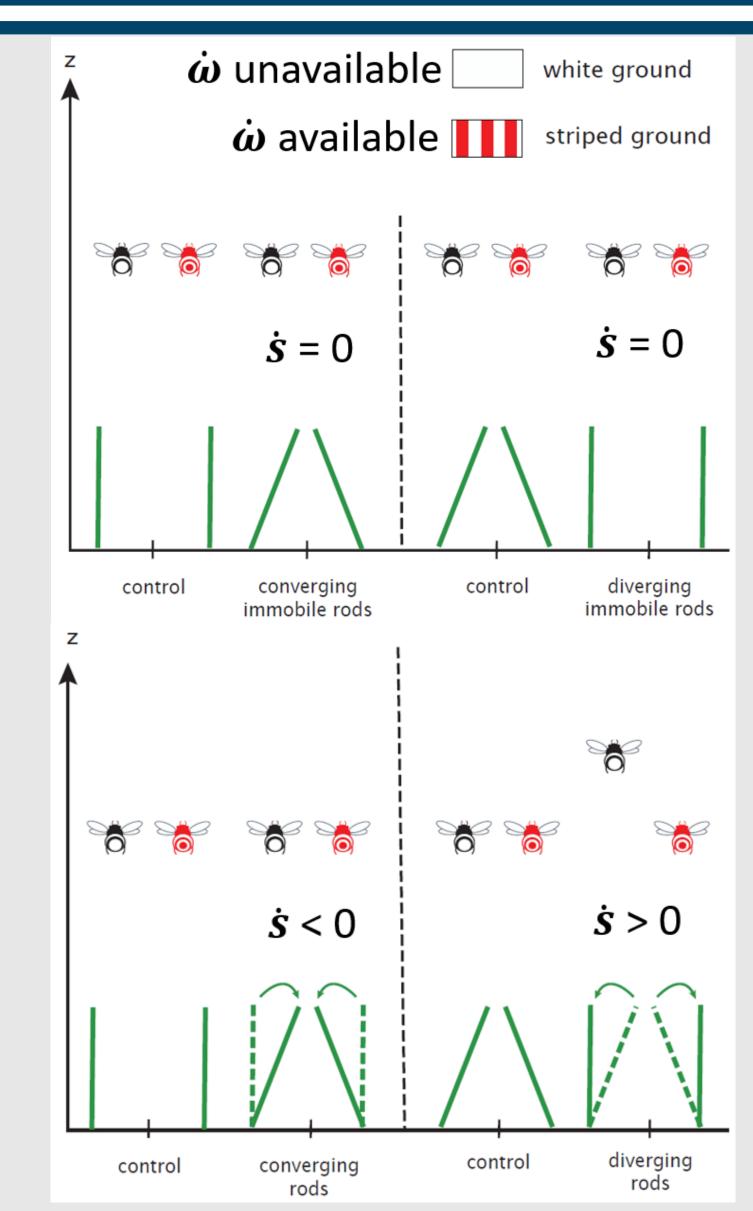
Experimental setup [9]





observed in humans [5, 6]

Predictions and results [9, 10]



- A bee perceiving a splay's enlargement will interpret a loss of altitude, so it will go up to maintain a null splay angle rate of change.
- A bee perceiving a splay's narrowing will interpret a gain in altitude, so it will go down to maintain a null splay angle rate of change.



• An experimental setup was designed to investigate whether the splay angle rate of change is implicated in bees' altitude control

Highlights

- A flight tunnel was built enabling specific manipulations of two optical invariants
- Splay angle rate of change is used by bees to control their altitude in a ground-following task
- Splay angle rate of change is used by bees only if the optical speed rate of change is less accessible



*This project was supported by a doctoral grant awarded to Aimie Berger Dauxère from Aix Marseille University.

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