Landmark Navigation without Snapshots: the Average Landmark Vector Model*

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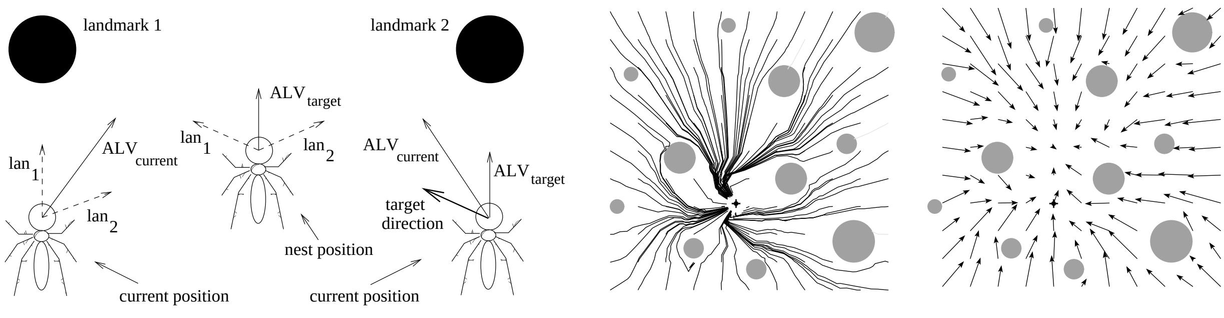
For almost two decades the view that insects store snapshots of retinal images, which they experience when they are in a target location, has dominated research in the field of visual landmark navigation. The so-called *snapshot* model [1] assumes that a panoramic image of the surroundings of the target position (nest, feeding station) is acquired and stored by the animal. The stored visual snapshot is then used to calculate the direction that the animal has to follow in order to return back to its target position. This is done by employing a matching mechanism that compares the current retinal image with the stored snapshot. This argument presupposes that there is an advantage in having a snapshot stored in memory. However, we show this not to be the case. Here we propose a new model for visual landmark navigation in insects, called the *Average Landmark Vector* model (ALV model). According to the ALV model, the animal does not need to store a snapshot: the only piece of information needed is the direction of the Average Landmark (AL) vector which is acquired by a simple summation of unit vectors pointing to landmarks (which are simple visual features, e.g. edges). The target direction is calculated at any position as the vector difference between the AL vectors at the target and the current position. This vector difference calculation replaces the "matching" process of the *snapshot* model (see figure). The new model does not only predict the results used in the studies with the snapshot model but it also gives different predictions for other experimental setups, a case that we shall test with the desert ant *Cataglyphis*. In addition, the single vector representation of the target direction suggests that there might be a closer link between the landmark navigation system and the celestial compass navigation system [2, 3]. In contrast to its computational simplicity (the only thing that the animal needs to record is one vector, and computing the target direction is achieved by a simple vector subtraction), the ALV model shows more robust behavior in complex realistic environments where a lot of landmarks are present and the *snapshot* model fails due to wrong matches between snapshot and current image.



Left: *Diagrammatic description of the ALV model. Every landmark in the visual field is associated with a unit vector. All landmark vectors are added to produce a single Average Landmark (AL) vector. At every point, the difference between the current vector and the vector at the target position gives the target direction.* **Center:** *Trajectories generated by the ALV model embedded in a simulated robot performing in a complex environment. Target position is at the cross.* **Right:** *AL vectors for the same environment.*

[1] B. A. Cartwright and T. S. Collett. Landmark learning in bees. *J. of comp. Physiol. A*, 151:521–543, 1983.

[2] R. Wehner, B. Michel, and P. Antonsen. Visual navigation in insects: Coupling of egocentric and geocentric information. *J. exp. Biol.*, 199:129–140, 1996.

[3] R. Wehner. The ant's celestial compass system: spectral and polarization channels. In M. Lehrer, editor, *Orientation and Communication in Arthropods*, pages 145–185. Birkhäuser, Basel, 1997.

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