From insects to robots and back

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When insects are flying forward, the image of the environment sweeps backward across their viewfield and forms an "optic flow" (OF) that depends on both the groundspeed and the distance to the ground (or to the lateral obstacles). Several studies have shown that insects are able to maintain a constant OF with regard to their surroundings while cruising and landing. To explain how insects could behave in this way, we introduced the concept of an *optic flow regulator*, that is, a feedback control system that adjusts a flight force so as to maintain the OF at a fixed set-point [1]. The variable that needs to be *measured* is neither groundspeed nor range but the ratio groundspeed:range - in other words, the *optic flow* - which the insect can access directly via motion detecting neurons. The *OF regulator* concept accounts for a number of seemingly disparate insect behaviours that were reported over the last decades [2]. Most reports are qualitative, but quantitative findings made on honeybees' landing can also be explained on the basis of this simple control system, including the constant descent angle observed in the bee's final approach [3]. In a similar vein, a honeybee trained to fly in a corridor [4] may rely on a *dual OF regulator* that adjusts both its forward and side thrusts - resulting in a forward groundspeed and a clearance to the walls, respectively - without any needs to *measure* groundspeed or range [5]. The *OF regulator* concept was simulated and physically implemented on board two kinds of aerial robots: a miniature helicopter for ground avoidance [1] (Fig.1) and a miniature hovercraft for lateral obstacle avoidance and cruise control in straight or tapered corridors [5]. The electronic OF sensors aboard [6] were derived from the housefly EMDs previously analyzed using single neuron recording combined with single photoreceptor stimulation [7].

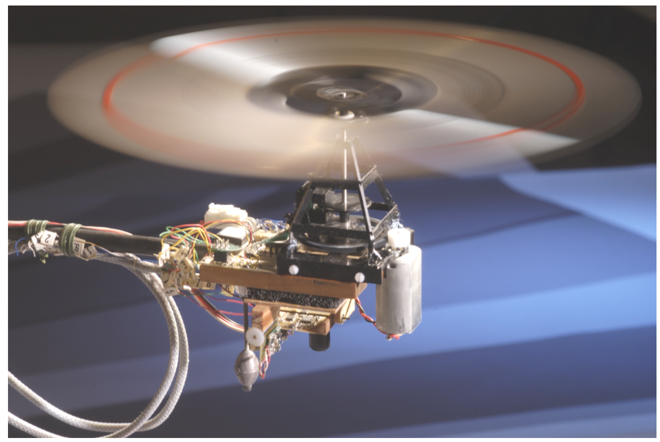

Fig. 1. The robot OCTAVE equipped with a ventral OF sensor and an *OF regulator* mimics insect behaviour in the vertical plane (takeoff, cruising, terrain following, landing, wind reaction)

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