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Skylight polarization heading sensor using waveplate retardance shift with incidence

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In nature, navigating insects such as ants, bees and flies rely on the polarization of light scattered by the sky to estimate their orientation relative to the sun, and thus orient themselves [1]. Numerous artificial sensors have been proposed in an attempt to reproduce their optical compass [2, 3, 4] but none is yet fully satisfactory for automotive use, either in terms of robustness, size, acquisition time or cost ($\sim\text{€}2,500$ for a polarimetric camera).

This study describes a innovative heading sensor architecture based on polarization pattern detection via an optical transformation (patent application [5]). This architecture is based on variations in the retardance of a waveplate as a function of the angle of incidence of the polarized light rays, resulting in the appearance on the image of iridescent colors, depending on the orientation of the incident rays and the state of polarization. The outcome is a low-cost, lightweight sensor that would cost about the same the color camera used (here a Raspberry Pi color camera, i.e. $\sim\text{€}30$).

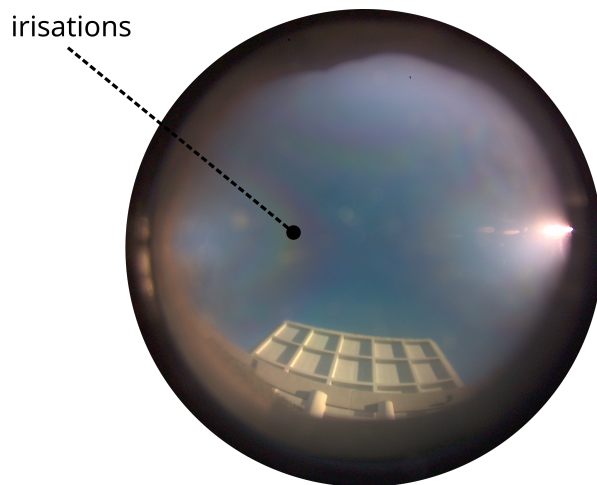


Figure 1: Outdoor image obtained by clear sky, in front of a building. Iridescent colors can be seen.

An optical simulation of the light-sensor interaction is presented, including a complete acquisition chain simulation (Rayleigh sky model, waveplate model in regard of incidence of rays, lens distortion, and color sensor).

A prototype based on the use of a plastic waveplate was built and fixated on a rotating motorized mount, allowing us to get outdoor images of sky with known sensor orientation regarding to the sun (Fig. 2).

Finally, methods for processing this type of images (Fig. 1) to estimate heading based on a convolutional neural network training with will also be discussed.



Figure 2: Motorized rotative mount supporting the optical sensor during outdoor experiments.

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