



A bio-inspired celestial compass for a hexapod walking robot in outdoor environment

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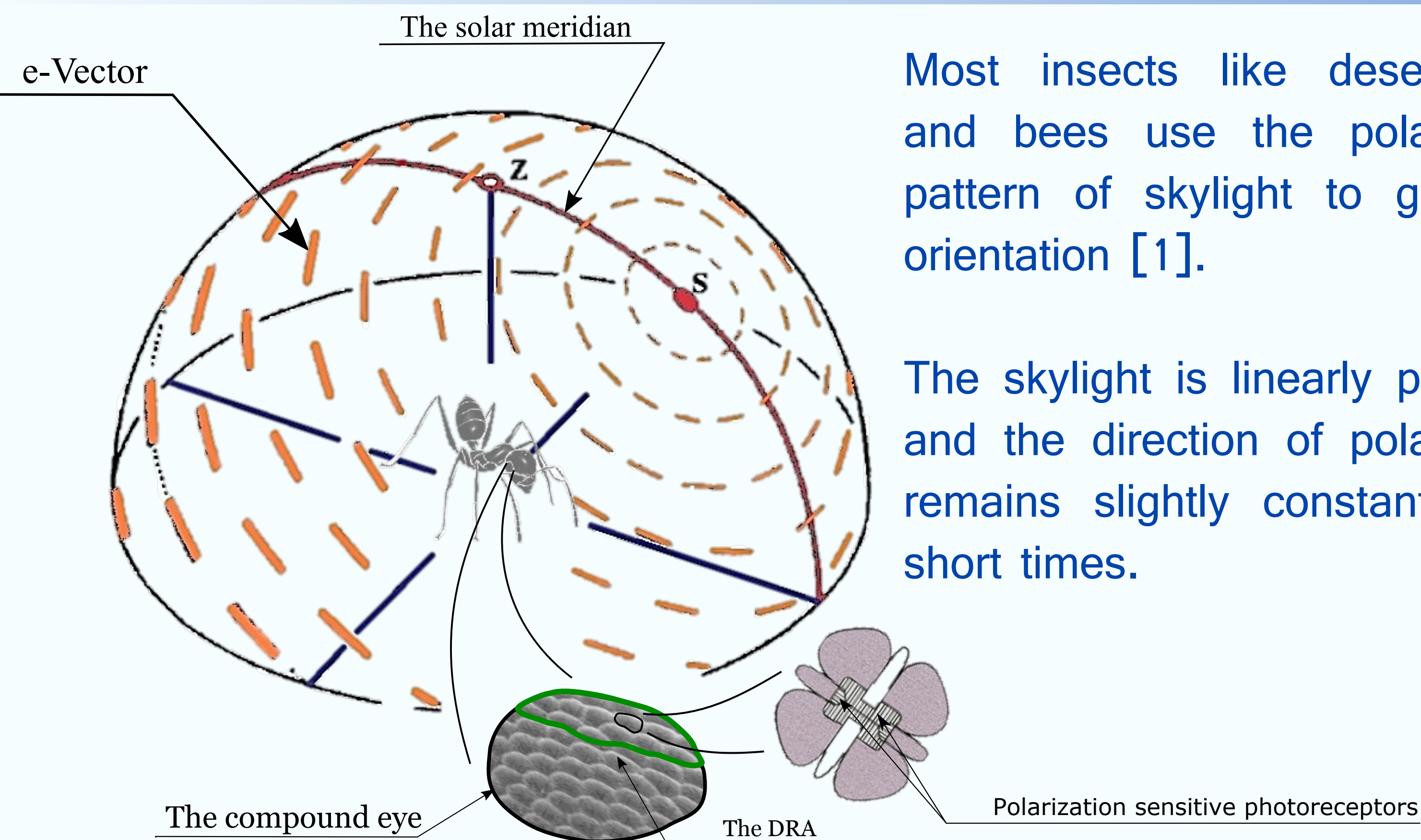
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A bio-inspired celestial compass for a hexapod walking robot in outdoor environment

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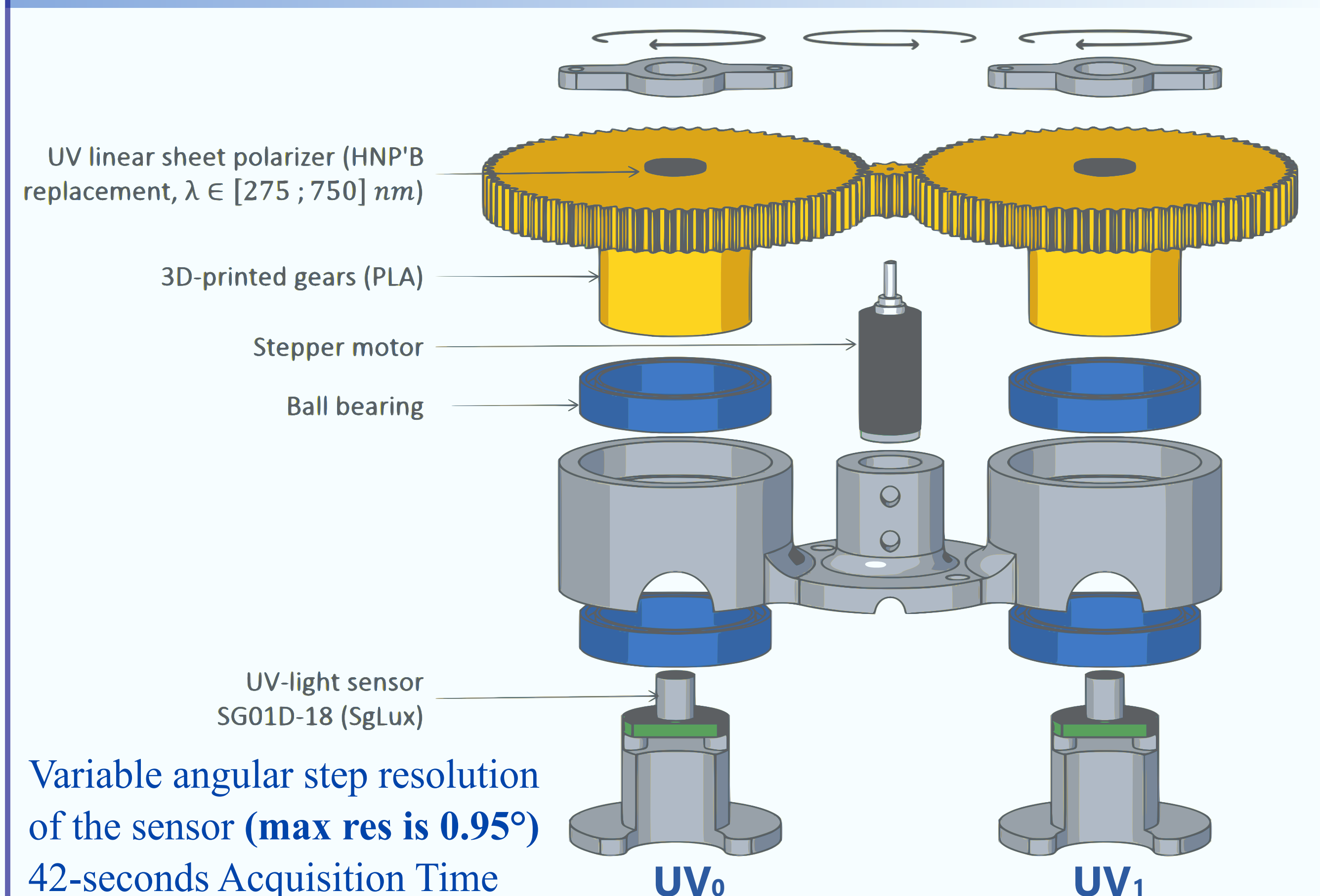
The polarized light detection in insects



Most insects like desert ants and bees use the polarization pattern of skylight to get their orientation [1].

The skylight is linearly polarized and the direction of polarization remains slightly constant within short times.

The celestial compass



The signal processing unit

The POL-sensor raw responses depending on the gear rotation angle x in $[0, 2\pi]$:

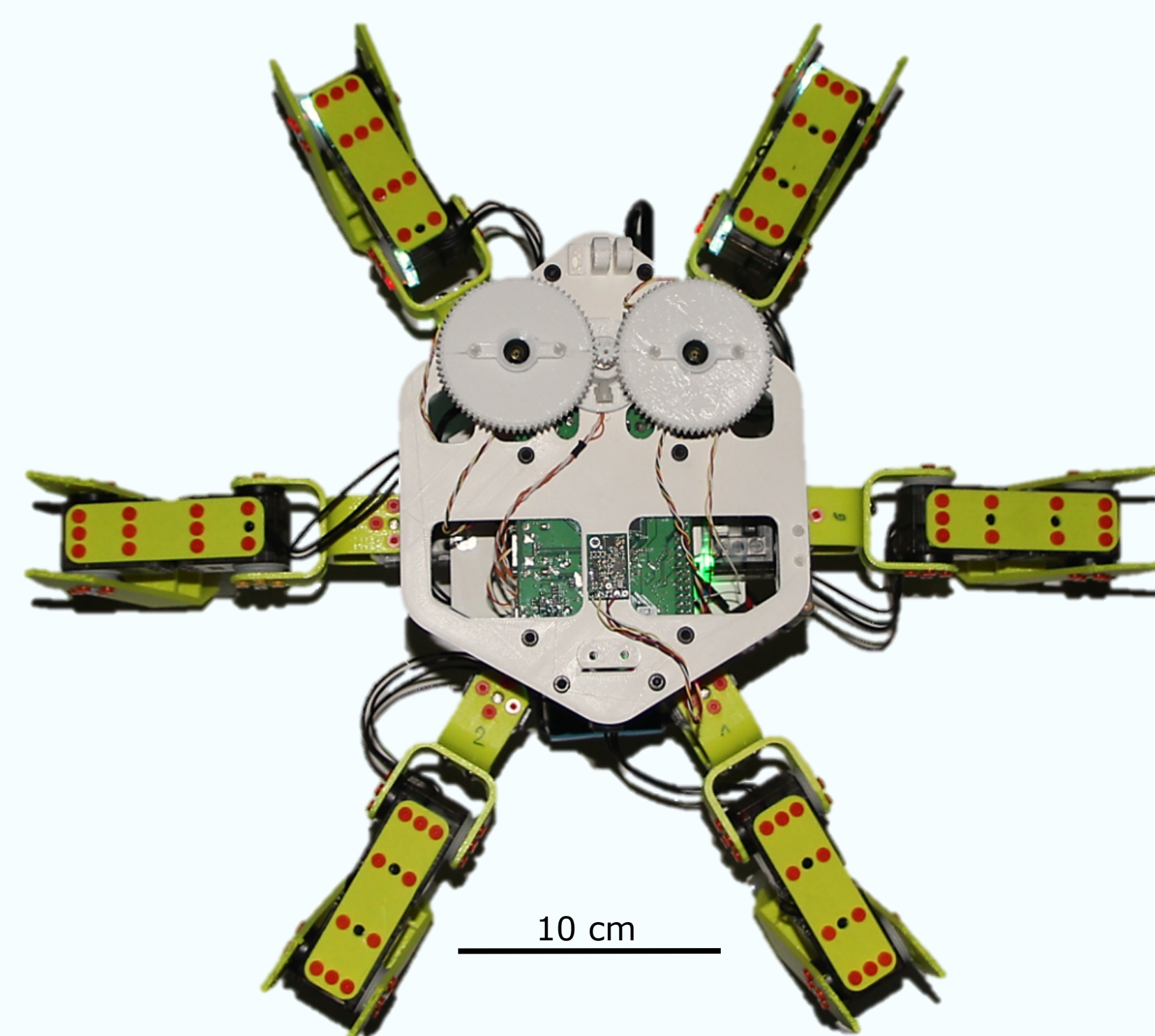
$$\begin{cases} UV_0(x) = A_0 + B_0 \cdot \cos(2(x + \psi)) \\ UV_1(x) = A_1 + B_1 \cdot \cos(2(x + \psi + \frac{\pi}{2})) \end{cases}$$

where ψ is the solar meridian direction angle in $[0, \pi]$.
We then define $p(x)$ as the log ratio of both normalized and corrected UV₀ and UV₁ POL-signals:

$$p(x) = \log_{10} \left(\frac{UV_1^{nc}(x)}{UV_0^{nc}(x)} \right)$$

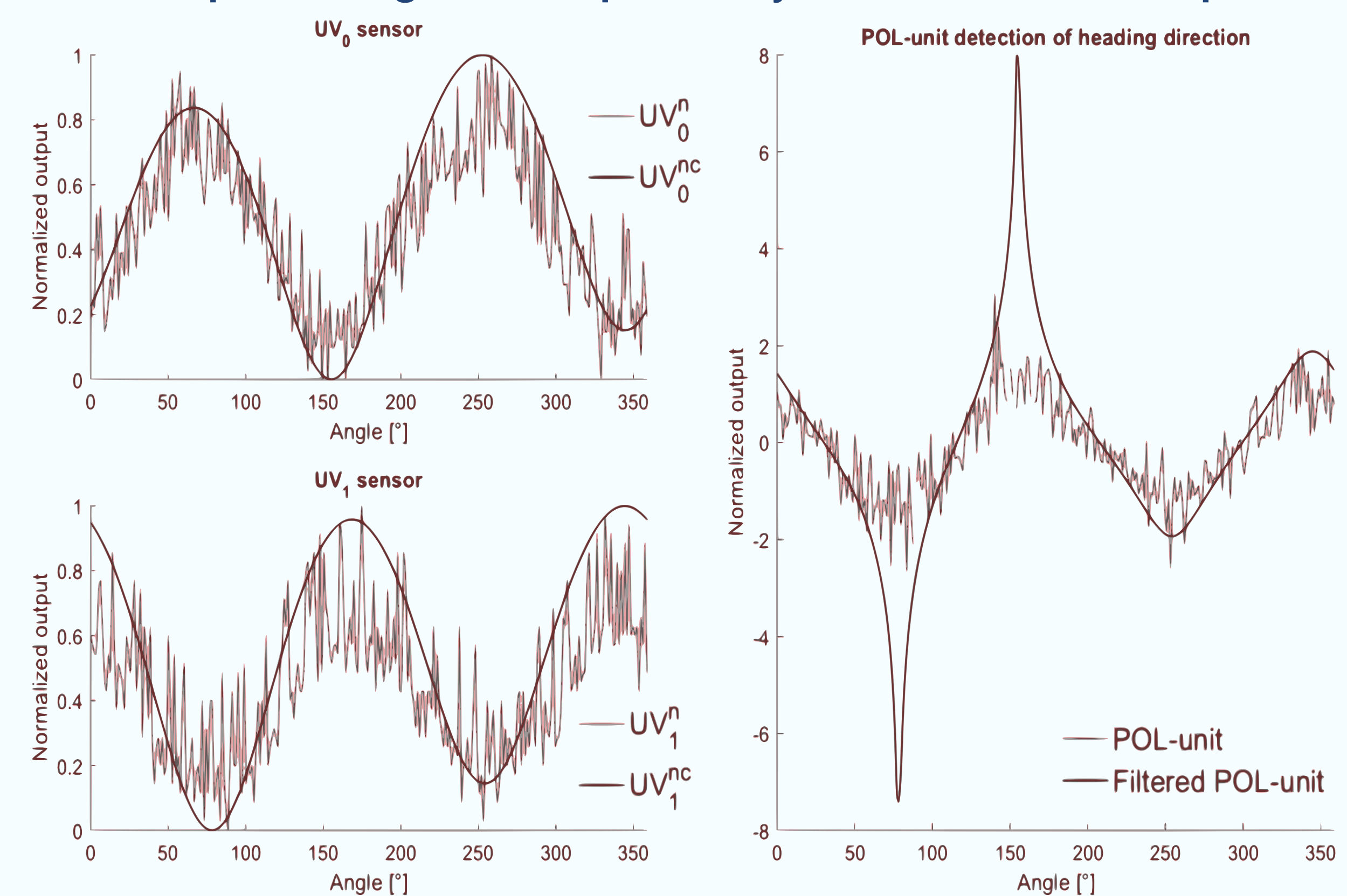
Finally, ψ is computed as follows:

$$\psi = \frac{1}{2} \left(\arg \min_{x \in [0; \pi]} p(x) + \arg \min_{x \in [\pi; 2\pi]} p(x) - \pi \right)$$



Top view of the Hexabot robot equipped with the UV-polarized light compass [2].

Example of signals acquired by the celestial compass

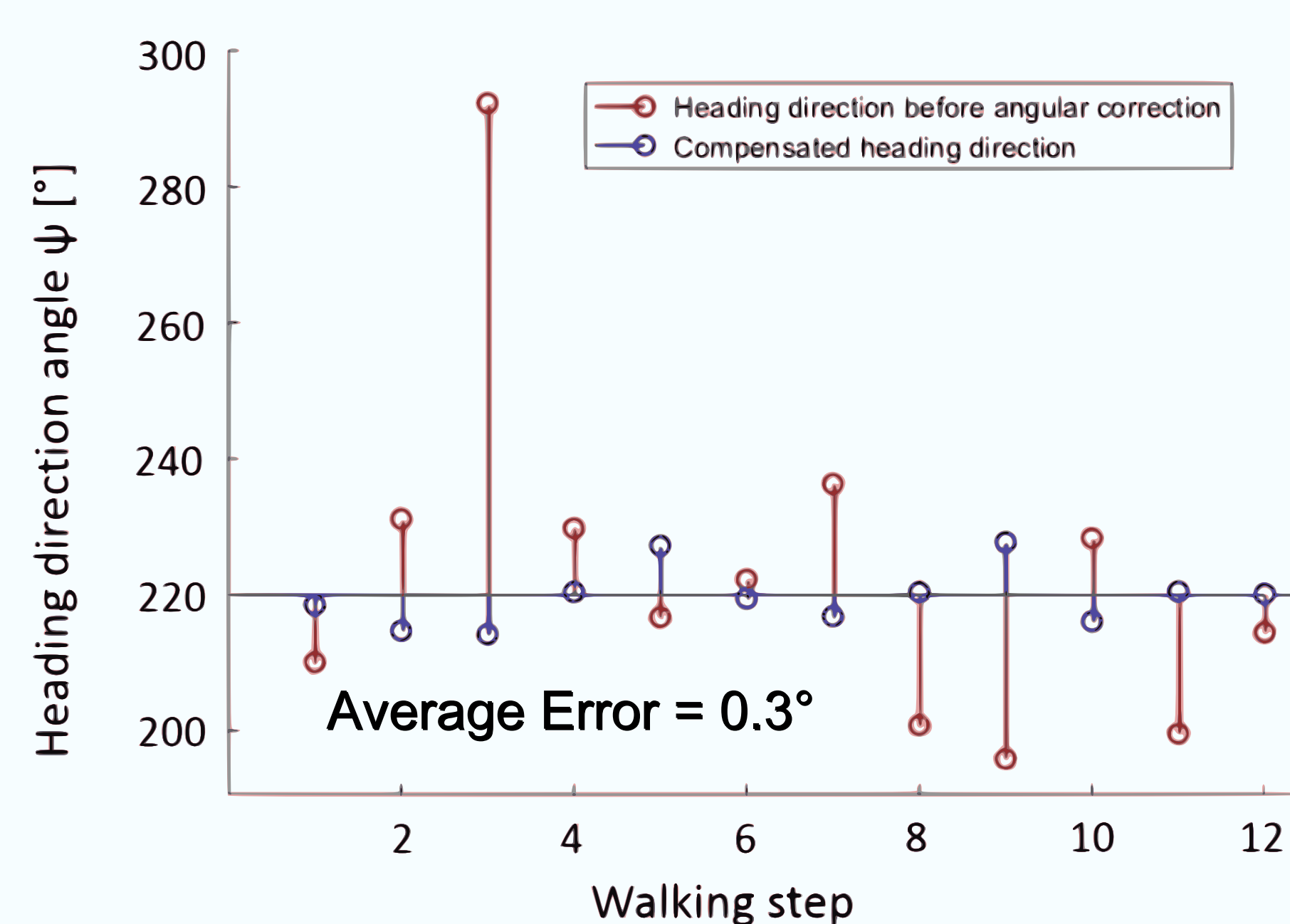


Results

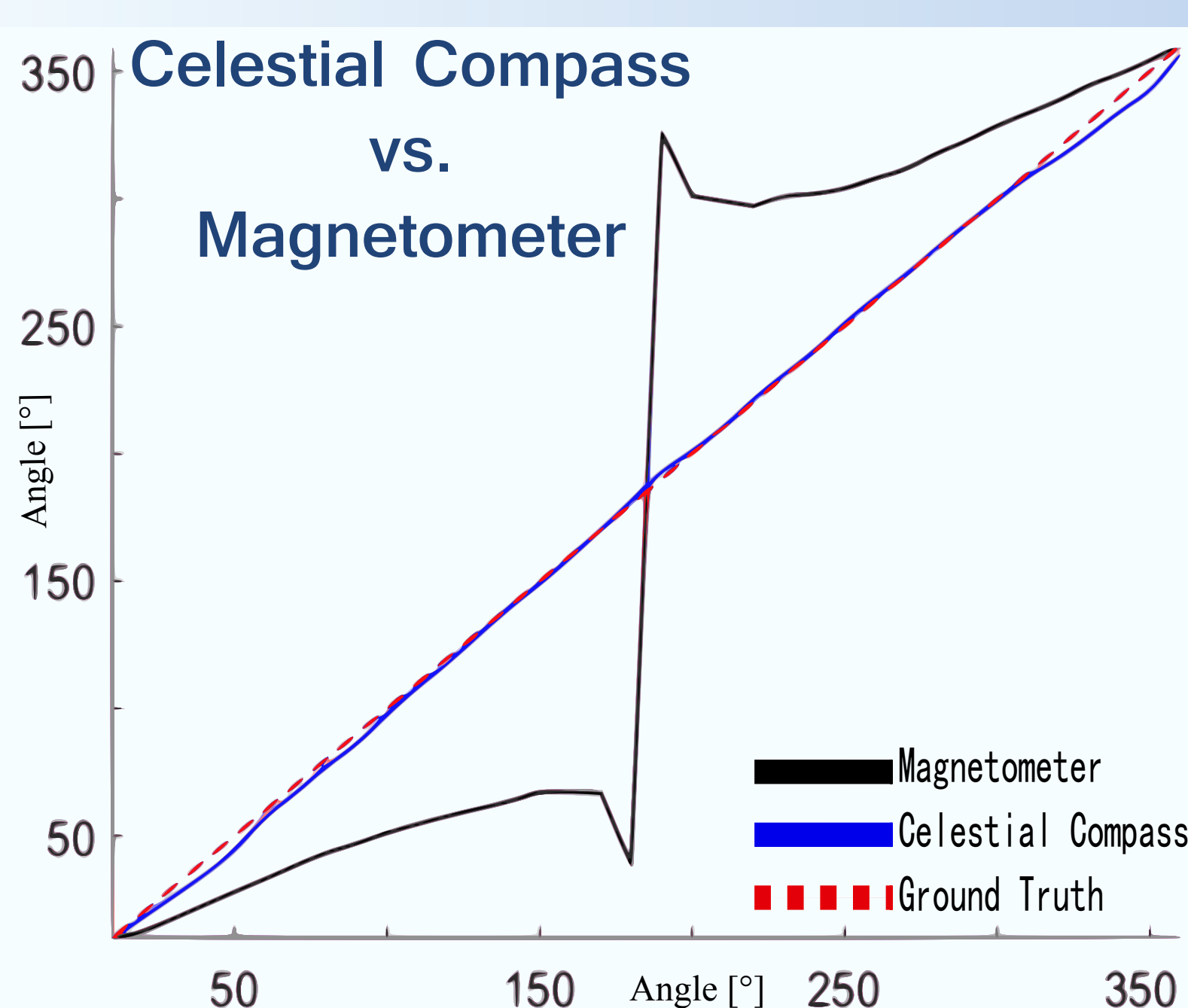
Performances of the celestial compass under various weather conditions [3]

Conditions	UV_{P-P}	Cv	n
Clear Sky, UV-index = 1	365	6%	42
Overcast Sky, UV-index = 1	102	22%	30
Clear Sky, UV-index = 7	1048	5%	72
Overcast Sky, UV-index = 7	144	19.5%	72

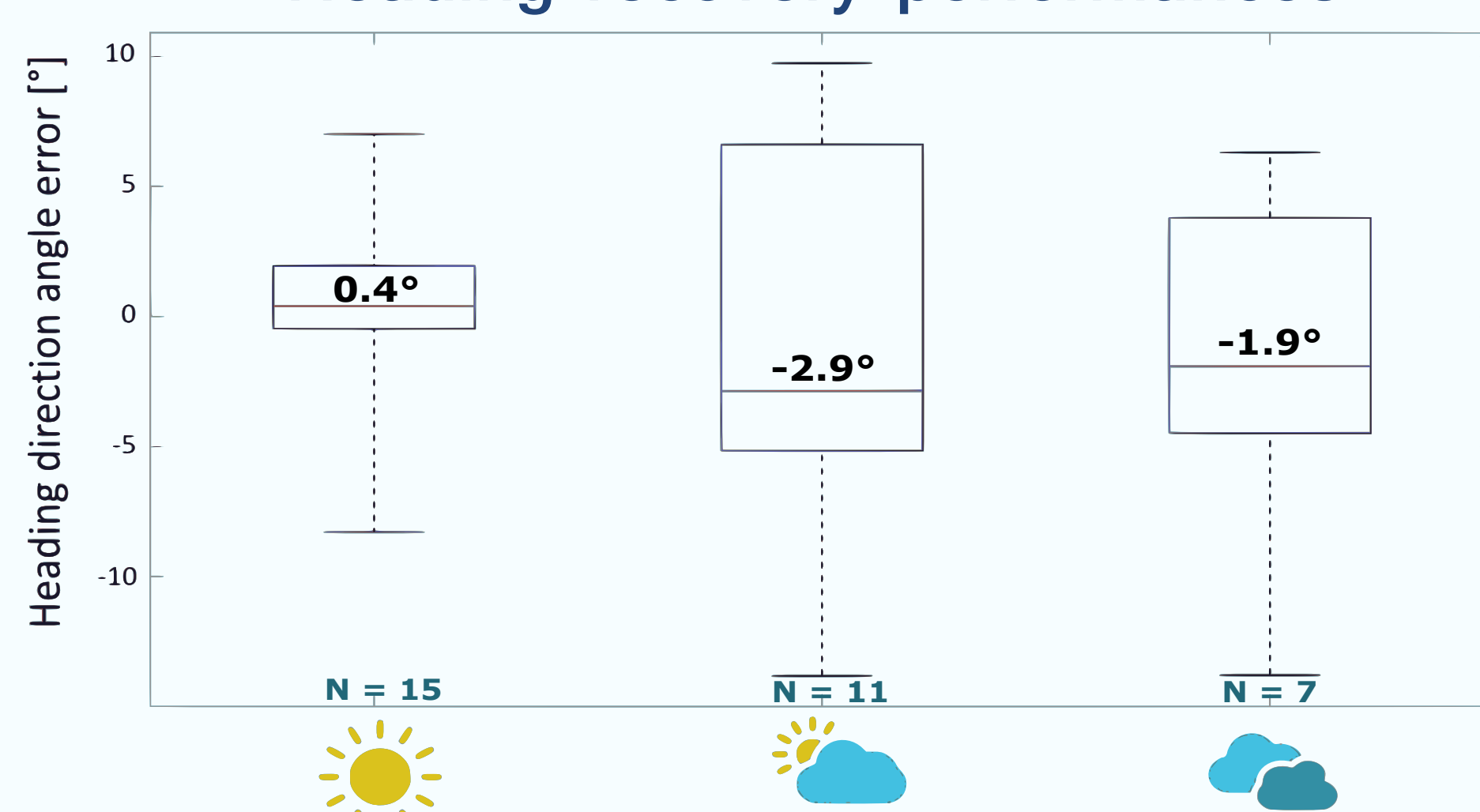
Heading lock over a straight-forward walking task



Celestial Compass vs. Magnetometer



Heading recovery performances



Conclusion

Heading direction error from 0.3° to 2.9° under various weather conditions: **High Reliability**.

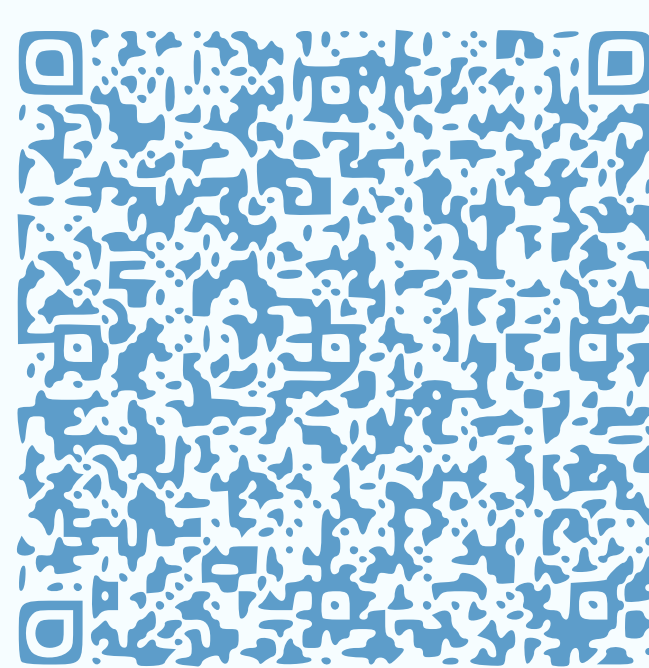
Sensory modalities very similar to those of insects : **robotic insect embodiment**.

Even under poor weather conditions, these results highlights **good precision** to make the optical compass **suitable for field robotics**.

References

- [1] T. Labhart. Polarization-opponent interneurons in the insect visual system. Nature, vol. 331, no 6155, pp. 435-437, 1988.
- [2] J. Dupeyroux, G. Passault, F. Ruffier, S. Viollet, J. Serres. Hexabot: a small 3D printed six-legged walking robot designed for ant-like navigation tasks. 20th IFAC World Congress, Toulouse, France, pp. 16628-16631, 2017.
- [3] J. Dupeyroux, J. Diperi, M. Boyron, S. Viollet, J. Serres. A bio-inspired celestial compass applied to an ant-inspired robot for autonomous navigation. Mobile Robots (ECMR), 2017 European Conference on. IEEE, 2017.

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