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

Julien Dupeyroux, Julien Diperi, Marc Boyron, Stéphane Viollet, Julien Serres

To cite this version:
Julien Dupeyroux, Julien Diperi, Marc Boyron, Stéphane Viollet, Julien Serres. A bio-inspired celestial compass for a hexapod walking robot in outdoor environment. 13ème Journée de l’Ecole Doctorale 463, Jun 2017, Montpellier, France. hal-01915658

HAL Id: hal-01915658
https://amu.hal.science/hal-01915658
Submitted on 7 Nov 2018
A bio-inspired celestial compass for a hexapod walking robot in outdoor environment

Julien Dupeyroux, Julien Diperi, Marc Boyron, Stéphane Viollet, Julien Serres.
Aix-Marseille Université, ISM, CNRS, Biorobotics Team, Marseille, France

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.

Variable angular step resolution of the sensor (max res is 0.95°)

Let $U_0$ and $U_1$ be the POL-sensor raw responses depending on $x$, the gear rotation angle in $[0, 2\pi[$:

$$
U_0(x) = A_0 + B_0 \cdot \cos(2x + \psi) \\
U_1(x) = A_1 + B_1 \cdot \cos(2x + \psi - \frac{\pi}{2})
$$

where $A_0$ and $A_1$ depend on the ambient UV-light and the inner offset of the UV-light sensors, $B_0$ and $B_1$ depend on the degree of polarization and the inner gain of the UV-light sensors, and $\psi$ is the solar meridian direction angle in $[0, \pi]$. We then define $p(x)$ as the log ratio of both normalized $U_0$ and $U_1$ POL-sensors:

$$
p(x) = \log_{10} \left( \frac{U_0^{nc}(x)}{U_1^{nc}(x)} \right)
$$

where $nc$ stands for normalized and corrected (only the first harmonic of the raw signal is considered). Finally, $\psi$ is computed using the $p(x)$ minima:

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

The signal processing unit

Results

Performances of the celestial compass under various weather conditions [4]

<table>
<thead>
<tr>
<th>Conditions</th>
<th>$U_0^{nc}$</th>
<th>$U_1^{nc}$</th>
<th>$\pi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>333.19</td>
<td>396.00</td>
<td>6</td>
</tr>
<tr>
<td>(b)</td>
<td>79.47</td>
<td>124.93</td>
<td>22</td>
</tr>
<tr>
<td>(c)</td>
<td>939.06</td>
<td>1377.11</td>
<td>5</td>
</tr>
<tr>
<td>(d)</td>
<td>176.11</td>
<td>111.22</td>
<td>21</td>
</tr>
</tbody>
</table>

Performances of reorientation after yaw displacements under various weather conditions [3,4]

Conclusion

Heading direction error from 0.3° under clear sky to 1.9° under worse weather conditions [3,4].

Even under poor weather conditions, these results suggest interesting precision to make the optical compass suitable for field robotics [3,4].

References