The ”navigational sense” in an insect-inspired independent navigation system

S. Zaleha M. Diah[1], Salmah B. Karman[1,2], O. Futterknecht[3], Ille. C. Gebeshuber[1,3]

[1]Institute of Microengineering and Nanoelectronics, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Malaysia;
[2]Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia;
[3]Institute of Applied Physics, Vienna University of Technology, Wiedner Hauptstrasse 8-10/134, 1040 Vienna, Austria.

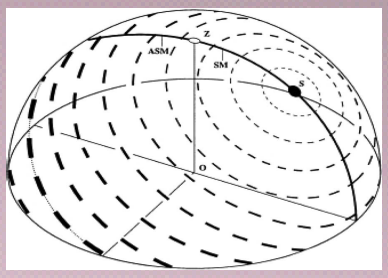
Abstract

Biological studies provide information on how animals such as desert ants and honeybees use polarized light in navigation. Animals have their own built-in navigational systems that shows distance and direction from the nest to the food source and they successfully navigate back using the celestial compass. Various bioinspired robot navigation systems are reported in the literature. In this presentation, we investigate possibilities of miniaturizing such a device down to the nanoscale, to expand the human sensory system with a‘navigational sense’ based on cutting edge technology.

Introduction

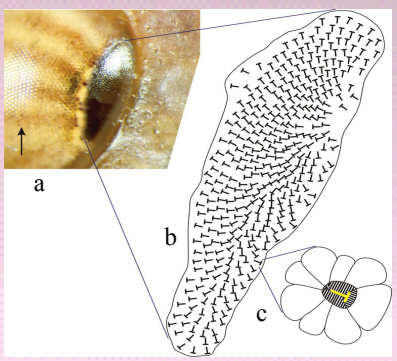
The animal kingdom prepared a great source of inspiration for the development of new and innovative navigation systems. Insects such as desert ants, honeybees, crickets and locusts can detect polarized light for navigation and searching for food. Many researchers work on systems inspired by the great navigational abilities of the desert ants.

Polarization pattern in the sky



Development of algorithm of model

The algorithm was derived from published studies on the anatomy of insect eyes and on published experiments with insect navigation.
Mechanism: Measuring the position of the 4 points in the sky, where the angle χ between the polarized e-vector and the meridian equals — $\pi/4$. The azimuth of these 4 points is invariant to variable cloud cover, provided that polarized skylight is still detectable below the clouds. The sum of these 4 azimuth values can be turned into a celestial compass.



Input-polarized light pattern → Data acquition and data processing → Output-device

Concept of polarization bioinspired MEMS device

a) compound eye of a locust – the part that is enlarged in b) is the dorsal rim area (DRA) that detects polarized light
b) arrangement of ommatidia in the DRA
c) each ommatidium contains eight photoreceptors that are strongly polarization sensitive

Outlook and conclusion

- The ability of insects to detect polarized light to navigate for food sources despite their diminutive brains and very small body size inspired many scientist to built bioinspired devices for robotics applications.
- Biology provides valuable input for technology and engineering to develop devices that can be used for humans for navigation.
- Knowledge transfer from biology to nanotechnology can be realized in various inspiring and creative ways.

References:

1. Möller R., D. Lambrinos, R. Pfeifer, R. Wehner (1998) Insect Strategies of Visual Homing in Mobile Robot, Proc. Computer Vision and Mobile Robotics Workshop, CVMR’98, 37-45 FORTH, Heraklion, Greece.
2. Smith F. J. (2009) Insect Navigation by Polarized Light. 2nd Int. IEEE-EMB Conf. on Biomed. Systems & Tech., BIOSIGNALS Component Conf.: 363-368, Porto, Portugal.
3. Homberg U., S. Heinze, K. Pfeiffer, M. Kinoshita and B. el Jundi (2011) Central Neural Coding of Sky Polarization in Insects. Phil. Trans. R. Soc. B 366: 680-687.