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Advances in GIScience and Current Developments

We believe that the central challenge we face today is to ensure
that globalization becomes a positive force for all the world's people.

United Nations Millennium Declaration, 2000

Towards a “Navigational Sense” for Humans: Biomimetic Polarized Light-based Navigation System

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KEY WORDS: Biomimetics, Human senses, MEMS in medicine, Polarized light navigation

ABSTRACT:

Biomimetics is an interdisciplinary approach that brings together biologists, physicists and engineers to produce optimized solutions for engineering problems. Principles of materials, structures and processes from living nature are identified, understood and transferred to the field of engineering, in order to, e.g., develop technological devices that can assist, enhance and expand human sensory abilities. This work discusses the concept development for a bioinspired polarized light-based navigation sensor built in miniaturized MEMS technology for medical applications. This sensor shall be the first step towards a “navigational sense”, and help people who are lost to find their way. With such a navigational sense-device, people could navigate and/or find their home independent of GPS technology. Current navigation systems are mostly dependent on the global navigation satellite system, the most fully operation system for global positioning. However the global navigation satellite system may be limited by the low precision of the signal in certain conditions such as in urban areas, intermittent coverage, and furthermore have high maintenance cost and is risk of being not globally accessible during conflict. Due to these risks, we initiated concept development of a new system that is GPS independent but possesses the global navigation satellite system performance. Our GPS independent polarization navigation sensor is a miniaturization of an existing polarized light based navigation system and shall be directly attached to the human body, delivering signals readily understandable even for patients with dementia and other disorders.

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1 Introduction

1.1 Biomimetics

Biomimetics involves transferring the deep principles of materials, structures and processes as found in living nature to the field of engineering in order to, e.g., develop technological devices that can assist, enhance and expand human sensory ability (Gebeshuber et al. 2009). Micro-electromechanical systems (MEMS) involve the integration of electrical, mechanical, physical, optical, chemical and/or biological phenomena of interest on a single chip. The bioinspiration of living nature’s principles could be realized through MEMS technology. Using MEMS devices, the range of human sensory ability could be enlarged: With the help of MEMS humans can perceive signals that would be otherwise too weak or too strong (X_1in Figure 1) or that are not covered by the human sensory system because of their type(X_2 in Figure 1) (Karman et al. 2011). The MEMS can then be linked to the human body (in our approach mainly *ex corpore* to avoid ethics conflicts) in order to assist, enhance and expand human sensory perceptions.

This paper discusses the potential development of a bioinspired MEMS polarized light navigation sensor for expanding the human sensory system towards a navigational sense. The mechanism and the key component of the sensor are inspired by the polarized light detection abilities of insects: Insects “see” the changing polarization of the skylight during the day and use it for navigation (Lambrinos et al. 2000). Polarization detection in insects is mediated by ommatidia of the dorsal rim area of their compound eyes (Labhart et al. 2009). Each ommatidium contains photoreceptors called rhabdoms that are strongly polarization-sensitive(Wehner 1983). With a device inspired by this ability of the insects, people could navigate without being dependent on GPS signals.

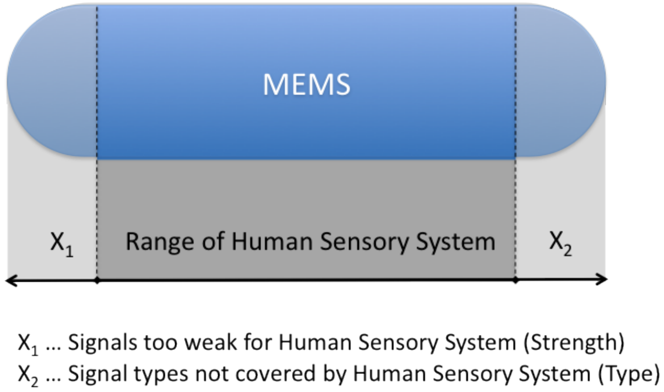

Figure 1. Functional Regions of Smart MEMS Sensors Compared to the Human Sensory System. Current MEMS cover nearly the whole range of the signals covered by people, plus signals that are too weak - or too strong - for us (X_1) and signals types that are not covered in humans by nature (X_2) (Karman et al. 2011, Makarczuk et al. 2011).

1.2 Trend of Navigation System Development

Navigation and finding the way home is very important for people, man-made devices and animals. Humans and animals navigate for finding food, in social activities, for communication and others. Over the years, starting from simple ways of navigation, people have developed a variety of navigation devices and systems, which are in many cases prerequisites for international communication, trading and others. As a consequence, systems such as VHF omnidirectional range (VOR) and tactical air navigation system (TACAN) were developed. Current navigation systems are mostly depended on the global navigation satellite system (GNSS), the most elaborate operation system for global positioning. The trend in GNSS augmentation started with the development of the Navy Navigation Satellite System (TRANSIT), US's Global Positioning System (GPS) and Russia's global positioning system (GLONASS) in 1960s and 1970s, continued by the launch of GNSS/Europe Global Navigation System (GALILEO) in 2012 and will be followed by the China's navigation system (COMPASS), Indian Regional Navigational Satellite System (IRNSS) and Japan's Quasi-Zenith Satellite System (QZSS) in the future (Mendizabal et al. 2009). The variability of function and integration of the new generation of GNSS has increased the market demand on related products (Mendizabal et al. 2009). However the application may be limited by low precision of the signal in certain condition such as in urban areas, intermittent coverage, and also by high cost maintenance and the risk to be shut down during times of conflict. Due to these risks there is need for systems that are GPS independent but possess the performance of GNSS.

1.3 Skylight Polarization Detection

The dynamic properties of skylight polarization provide useful information for various navigating animals and serve as the basis for a related man-made device. The static relationship between E-vector orientation and the sun's azimuth (Michael L 1980) serve as basis for the development of a bioinspired polarized light based navigation system as an alternative to GNSS.

The qualitatively robust pattern of polarized skylight direction can be obtained in any condition and even if the sun is not directly visible (Hegedus et al. 2007a), such as under canopy and foliage (Hegedus et al. 2007b), and on overcast and hazy days. This is because only a small section of clear sky needs to be visible for the animals to obtain a compass bearing for accurate navigation (Dacke et al. 1999). The polarization angle pattern of the cloudy sky is determined predominantly by scattering on cloud particles themselves (Hegedus et al. 2007a). Furthermore, the detection of polarization of downwelling light under clouds or canopies is most advantageous in the ultraviolet (UV) range; due to wavelength-dependent scattering properties in this spectral range the risk is the smallest that the degree of polarization is lower than the threshold of polarization sensitivity in animals (Barta and Horvath 2004).

2 Polarized Light Based Navigation Devices

Bioinspiration for polarized light navigation sensors has been realized both in the development of GPS independent navigation systems and in improvement of current GPS systems. Such devices comprise a novel polarized light based navigation sensor, a polarized light compass for mobile robot navigation and a polarized light based GPS/Inertial Navigation System (INS) integrated navigation system (Chu et al. 2008, Shashar et al. 2004). To improve the current GNSS system, the error measurement system needed to be improved (Lu et al. 2006). A pure INS integrates several differential equations containing inertial measurements to provide a navigation solution. The small errors in the measurements can lead to large velocity and position errors if allowed to integrate without correction for long times periods. Thus, to correct for this problem, the navigation system errors must be periodically corrected by external aiding instrumentation. Fan et al., 2009 (Fan et al. 2009) have implemented a new integrated navigation solution with polarized light assisting with geomagnetism and GPS.

Lambrinos et al. invented a GPS independent polarization compass model that is mimicking navigation of desert ants (Lambrinos et al. 2000). Enhancement of this polarization compass principle has lead to the development of the novel polarized light navigation sensor that has been developed by Chu and co-workers (Chu et al. 2009, Chu et al. 2008, Chu et al. 2007a, Chu et al. 2007b, Zhao et al. 2009) as well as the improvement in the error measurement. The key components of the polarization compass consist of a polarization sensor and a log-ratio amplifier inspired by the insects' polarized light sensitive photoreceptors and polarization neurons, respectively(Chu et al. 2007a, Chu et al. 2007b, Lambrinos et al. 2000). This device has large size electronic components such as photodiodes, polarizers, blue transmitting filters and log ratio amplifiers, and additionally needs a computer as controller. The orthogonal arrangement of the microvilli in the insects' rhabdomere of the dorsal rim area has inspired the development of the CMOS based wire grid polarizer which is used in a polarization sensor (Fantao et al. 2007, Sarkar et al. 2010b). Using newly designed polarization sensors, the changes in linear polarization underwater as a function of distance from a standard target also could be measured (Shashar et al. 2004).

3 Concept Development

The bioinspired polarized light based navigation device has been developed by a number of groups for more than a decade now (Chu et al. 2008, Fan et al. 2009, Lambrinos et al. 2000, Lu et al. 2006). Most applications are intended for mobile robots' navigation compasses and vehicles' navigation systems. Due to certain limitations, none of the devices are used for application directly on the human body, which would offer benefits regarding their potential medical applications.

As in insect, the polarization compass is located on the top area of the head, where this area is directly facing the sky. By mimicking the natural system, the novel polarized light based compass (PL-compass) needs to be placed on the top area of the human head (Figure 2). To avoid difficulties to the human caused by the device's size and weight, device miniaturization is important. The miniaturization could be done via MEMS technology. In this paper, the concept for a novel miniaturized MEMS PL-compass is introduced. The device consists of two major parts the polarized light detection unit and the signal processing unit (Table 1 and Figure 3). The polarized light detection unit consists of coupled metallic wire grid nanopolarizers-photoelectric material arrays (Sarkar et al. 2010a), while the nanoprocessing system will be used for signal processing unit (Yan et al. 2011). The existing PL-compass that is employed for mobile robots is of too bulky size, consisting of large size electronic components, making it not suitable for the human-contact application. The polarized light detection unit of the existing PL-compass consists of polarizers, transmitting filters and photodetectors, while the signal processing unit consists of the components such as the LOG104, analog to digital converter, ARM7TDMI based center processor and further components (Chu et al. 2008).

The workflow of the novel miniaturized MEMS PL-compass will remain exactly same as in the current existing device (Figure 3). A polarized light detection unit will detect the polarized light pattern as input. The input signal will be analyzed and processed in data acquisition and processing units, respectively, before being forwarded to the output channel for action. The metallic wire grid nanopolarizer has already been successfully employed for the development of a CMOS based polarized light image sensor (Sarkar et al. 2010a). By employing the nanoprocessing system, the size of the center processor and electrical circuit could be reduced (Yan et al. 2011). This would lead to the realization of a miniaturized PL-compass that can be applied for human's *navigational sense*.

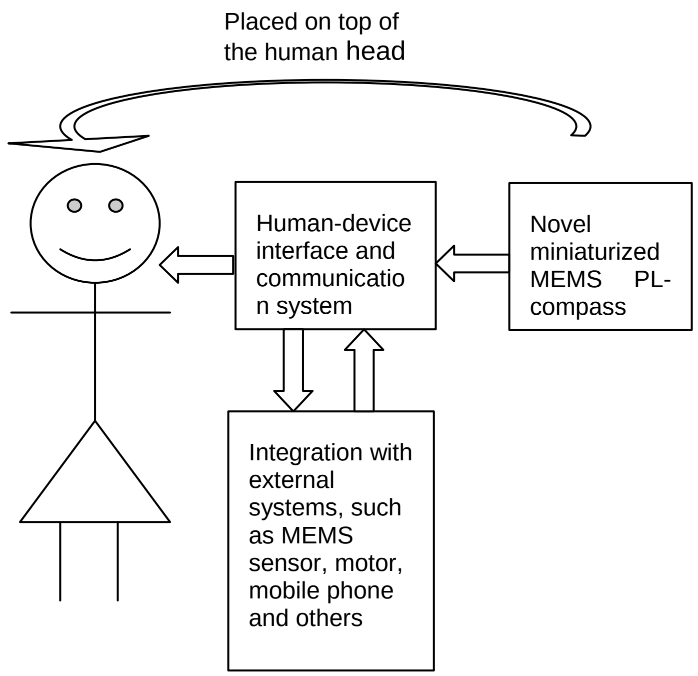

Figure 2. Schematic diagram of concept and application of novel miniature MEMS PL-compass for human navigation and medical application.

	Existing device	New device
Size	Macrosize	Nanosize
Application	Mobile robot	Human
Components	3 units of polarization direction analyzers (2 pairs of polarizers with photodetectors and transmitting filter in each units) with signal processing unit	Novel MEMS PL-compass with a metallic wire grid nanopolarizer amended in a photoelectric material and nanoprocessing system

Table 1. Components of polarized light compass (PL-compass)

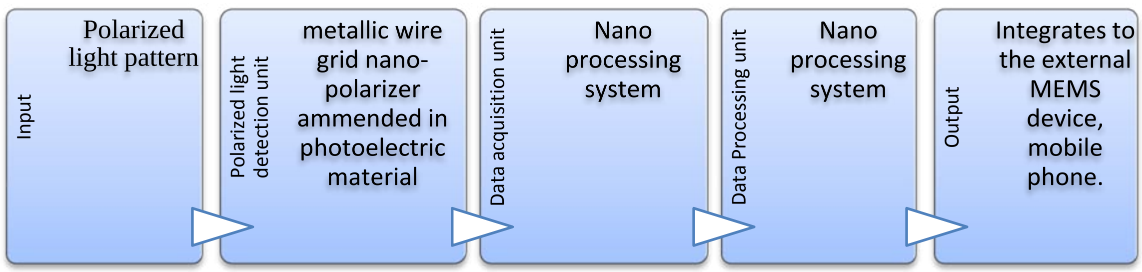

Figure 3. Flowchart of mechanism of novel MEMS PL-compass

4 Outlook and Discussion: MEMS, GIS and Health

The implementation of the bioinspired polarized light navigation sensor for enhancing the human sensory ability towards the “navigational sense” requires the connection between the devices and the human body. Thus, miniaturization of the existing devices needs to be performed -this can be successfully done with MEMS technology (Gilleo 2005). Using MEMS technology, the existing devices could be integrated with various techniques and devices and can enable the ability to obtain the desired characteristics in terms of shape, structure, bandwidth, working range, quality, and others. MEMS also can provide systems or devices with high functionality and intelligence (Makarczuk et al. 2011). Integration techniques can lead to simple manufacturing methods. The MEMS can then be linked to the human body (mainly *ex corpore* to avoid ethics conflicts) in order to enhance the human sensory perception towards a polarized light based "navigation sense". This sense would be very beneficial to people at risk such as blind people, people bound to a wheelchair, people with Parkinson's disease and lost people including children.

The integration of the human's navigational sense with geographical information systems (GIS) such as from a smart phone will offer paramount potential in upgrading human health monitoring systems. Some existing devices, devices in development phase and devices that will be developed in the future are depicted in Figure 4.

Figure 4. Phases of GIS implementation in human health monitoring systems

As "protosystems" we depict systems that "became" GIS systems, e.g., smart mobile phones that can calculate the position by extrapolating from the position of the mobile phone masts in the surroundings. Concerning the improvement of existing systems: push technology will be the future here. We will know where we are, and where all our friends are. And we will not just know the distance as the crow flies, which is in many cases useless (e.g. when the person and her friend are 200 meters apart, but there is a highway between the two, and they do not have a car) - the "user-centered distance" is the one that really counts: If for example the person is just one station by the train away from her friend, and the train comes soon, he is closer than when his friend is 200 meters away, but three streets which cannot be crossed are between the two. An example for a future system is the Google glass, a high technology system that provides the eye of the user with huge amounts of additional information.

Potential medical uses of combining GIS with MEMS: the position of the user and his biovital data could be transmitted to a central server, in a time triggered way (e.g. every 20 minutes). As soon as the health of the user goes down, the system would switch from time triggered to event triggered, and if the health state of the user reaches a certain tragical threshold, the central servers would send an ambulance to his position, and point him towards a shop (potentially with a navigational device that is directly coupled to the body) where there is somebody who can help him (and the system also would verify that this person is there and available) - somebody with a defribrillator for example if the user has heart problems, or somebody with experience in first aid. Another potential medical application of a combinational MEMS and GIS would be the following: when the user is on a bicycle tour, the route he is cycling could be adapted to his current health state, and also to the weather. This would of course also work when hiking or kayaking. If the user is in a group, the system could recommend splitting of the group, where the weaker ones stay together and take the easier way for example - or it could recommend that all stay together for health and safety reasons.

The combination of MEMS, GIS and health have a bright future.

5 References

Barta, A. and Horvath, G., 2004. Why is it advantageous for animals to detect celestial polarization in the ultraviolet? Skylight polarization under clouds and canopies is strongest in the UV. *Journal of Theoretical Biology*, vol. 226, (4) pp. 429-437.

Chu, J., *et al.*, "Application of a novel polarization sensor to mobile robot navigation," in *International Conference on Mechatronics and Automation, ICMA 2009.*, 2009, pp. 3763-3768.

Chu, J., *et al.*, 2008. Construction and performance test of a novel polarization sensor for navigation. *Sensors and Actuators A: Physical*, vol. 148, (1) pp. 75-82.

Chu, J., *et al.*, "Research on a Novel Polarization Sensor for Navigation," in *International Conference on Information Acquisition, 2007. ICIA '07.* , 2007a, pp. 241-246.

Chu, J., *et al.*, "Design of a Novel Polarization Sensor for Navigation," in *International Conference on Mechatronics and Automation, 2007. ICMA 2007.* , 2007b, pp. 3161-3166.

Dacke, M., *et al.*, 1999. Built-in polarizers form part of a compass organ in spiders. *Nature,* vol. 401, (6752) pp. 470-473.

Fan, Z., *et al.*, 2009. The Implementation of a New Integrated Navigation Solution with Polarized-light Assisting with Geomagnetism and GPS. *CNKI - Geomatics and Information Science of Wuhan University,*

Fantao, M., *et al.*, "The design of the sub-wavelength wire-grid polarizer," in *Nanotechnology, 2007. IEEE-NANO 2007. 7th IEEE Conference on*, 2007, pp. 942-946.

Gebeshuber, I. C., *et al.*, "Nanomedicine and Biomimetics: Life Sciences Meet Engineering & Physics," presented at the 3rd Vienna International Conference Nano-Technology-VIENNANO '09, 2009.

Gilleo, K., "MEMS in medicine," in *Circuits Assembly, allflexinc.com,* ed: LLC ET-Trans, 2005.

Hegedus, R., *et al.*, 2007a. Polarization patterns of thick clouds: overcast skies have distribution of the angle of polarization similar to that of clear skies. *Journal of the Optical Society of America a-Optics Image Science and Vision,* vol. 24, (8) pp. 2347-2356.

Hegedus, R., *et al.*, 2007b. Imaging polarimetry of forest canopies: how the azimuth direction of the sun, occluded by vegetation, can be assessed from the polarization pattern of the sunlit foliage. *Applied Optics,* vol. 46, (23) pp. 6019-6032.

Karman, S. B., *et al.*, 2011. On the way to the bionic man: A novel approach to MEMS based on biological sensory systems. *Advanced Material Research,* vol. 74, pp. 265-268.

Labhart, T., *et al.*, 2009. Specialized ommatidia of the polarization-sensitive dorsal rim area in the eye of monarch butterflies have non-functional reflecting tapeta. *Cell and Tissue Research,* vol. 338, (3) pp. 391-400.

Lambrinos, D., *et al.*, 2000. A mobile robot employing insect strategies for navigation. *Robotics and Autonomous Systems,* vol. 30, (1–2) pp. 39-64.

Lu, H., *et al.*, "Principles and Applications of Polarized-light-aided Attitude Determination in Integrated Navigation," in *Control Conference, 2006. CCC 2006. Chinese*, 2006, pp. 483-488.

Makarczuk, T., *et al.*, "Biomimetic MEMS to assist, enhance, and expand human sensory perceptions: a survey on state-of-the-art developments," in *Proc. SPIE*, 2011.

Mendizabal, J., *et al.*, 2009. *GPS and Galileo : Dual RF Front-End Receiver Design, Fabrication, and Test.* Mc Graw Hill, 2009.

Michael L, B., 1980. Dynamic patterns of skylight polarization as clock and compass. *Journal of Theoretical Biology,* vol. 86, (3) pp. 507-512.

Sarkar, M., *et al.*, "Integrated polarization analyzing CMOS Image sensor for autonomus navigation using polarized light," in *Intelligent Systems (IS), 2010 5th IEEE International Conference*, 2010a, pp. 224-229.

Sarkar, M., *et al.*, 2010b. Biologically inspired autonomous agent navigation using an integrated polarization analyzing CMOS image sensor. *Procedia Engineering,* vol. 5, (0) pp. 673-676.

Shashar, N., *et al.*, 2004. Transmission of linearly polarized light in seawater: Implications for polarization signaling. *Journal of Experimental Biology,* vol. 207, (20) pp. 3619-3628.

Wehner, R., "The perception of polarized light," in *The Biology of photoreceptor*, ed Cambridge: Cambridge University Press, 1983, pp. 331-369.

Yan, H., *et al.*, 2011. Programmable nanowire circuits for nanoprocessors. *Nature,* vol. 470, (7333) pp. 240-244.

Zhao, K., *et al.*, 2009. A Novel Angle Algorithm of Polarization Sensor for Navigation. *Instrumentation and Measurement, IEEE Transactions on,* vol. 58, (8) pp. 2791-2796.

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The "Navigational Sense" in Living Nature: A Survey for Engineers

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KEY WORDS: Navigation, Nature, Bioinspired, Path integration, Polarised light

ABSTRACT:

In biomimetics, materials, processes and systems in nature are analysed, the underlying principles are extracted and subsequently applied to science and technology. Once the basic principles of biological systems are understood, the engineer can start to work on the related bioinspired device. Many animals use combination strategies to orient themselves, and to navigate. They use long-distance and/or short-distance clues to forage and orient themselves to return back to their nest or hive, sometimes for kilometres. Famous navigators from the animal world are the honeybees (Apis mellifera) and the desert ants (Cataglyphis bicolor). Both use polarization-based navigation. The ants became model organisms for engineers on how they find their way back. Neurobiological and behavioural research yielded a model that was adapted for robot navigation. The skylight pattern of polarised light (the e-vector pattern) provides one of the cues for navigation. A specialized part of the insect compound eye has a small group of ommatidia and is located in the dorsal rim area. These detect the polarised light. Each ommatidium contains two photoreceptors and is strongly polarization sensitive, with orthogonally arranged analyser directions. Understanding the theory of the mechanism behind polarised light detection and subsequent navigation in insects is important in the development of a microelectromechanical (MEMS) based navigational device that uses the polarisation of the skylight as input signal. Such a navigation device is an alternative method for navigation, independent of GPS. The presentation will give a survey of biological principles regarding navigation systems based on polarised skylight. The presenter and first author is a biologist who has over the last year acquired experience in talking to engineers, discussing biomimetic approaches.

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1 Introduction

1.1 Motivation

'*Sense of direction is something you enter this world with and if it wasn't conferred upon you as a birthright you'll never acquire it, no matter how hard you study. I was born with this gift and it is impossible for any of us who are so gifted to explain how we do it.'* (*The Australian bushman Lindsay sat firmly on one side)*

In the past decade, a large number of robots were built that explicitly implemented biological navigation behaviours. Reviewed biomimetic approaches using a framework that allows for a common description of biological and technical navigation behaviour. The review shows that biomimetic systems make significant contributions to two fields of research: First, they provide a real world test of models of biological navigation behaviour; second, they make new navigation mechanisms available for technical applications, most notably in the field of indoor robot navigation. While simpler insect navigation behaviours have been implemented quite successfully, the more complicated way-finding capabilities of vertebrates still pose a challenge to current systems (Mallot and Franz 1999).

1.2 Bioinspired

The nature and organization of biology and engineering are very different. Organisms develop through a process of evolution and natural selection; biology is largely descriptive and creates classifications, whereas engineering is a result of decision-making; it is prescriptive and generates rules and regularities (Vincent et al. 2006). Biomimetics involves transferring the principles of materials, structures and processes as found in living nature, to the field of engineering in order to, e.g., develop technological devices that can assist, enhance and expand human sensory ability. Biomimetics has not only united the fields of biology and medicine in order to benefit mankind, but has also integrated the principals of other applied sciences, including physics, tribology, chemistry and engineering (Gebeshuber, Majlis, and Stachelberger 2009). The structure of living organisms is highly elaborate. Natural materials and processes are refined and in some cases extremely complex, and MicroElectroMechanical Systems (MEMS) devices seek to reproduce nature's perfection. This paper provides an overview of senses of organisms as already represented in existing MEMS devices and uses push-pull analysis to review the potential these devices have for assisting, enhancing and expanding the human sensory system.

2 Biological Navigation Sense

2.1 Biological navigation systems

Researchers working on the exact capabilities and limitation of mapping and navigation systems used in nature provide valuable information including knowledge on what animals and insects can achieve using their own sensory and higher processing systems, and the theories and models of mechanism they use in the process (Milford 2008). Animals can use the great source of information to orientate themselves and for successful navigation they need to know the direction and the distance (Rodrigo 2002).

2.2 Navigation strategies in insects

Capable navigators in the animal world occur in vertebrates and invertebrates such as molluscs, cephalopods, and in all major arthropod groups, including insects and crustaceans (Wolf 2011). Navigating animals have the ability to identify and maintain a course or path from one place to another (Gallistel 1990). Insects are amazing animals with special anatomy and characteristics in adaptation of their life especially the ability of to return back to their hive after navigated for a kilometre or even more. Many animals navigate either long-distance or short-distance to forage, and they can return back to their nest or hive from places many kilometres away. Long-distance navigators include desert ants (Wehner 2003; Merkle and Wehner 2010; Cruse and Wehner 2011) and the honeybee (Collet 2008). Monarch butterflies who travel seasonally over thousands of kilometres (Brower 1996; Reppert, Gegear, and Merlin 2010) are different to the ants, bees, wasps and other social Hymenoptera. Worker honeybees fly from their nest for many kilometres foraging for pollen and nectar, and return back to their nest to inform nest mates on food sources using highly specific ways of communication (Frisch 1967). Insects use skylight polarization for different orientation tasks, for example for course control, navigation, foraging and others (Stalleicken, Labhart, and Mouritsen 2005). Polarization-based navigation specialists are for example the honeybee (*Apis mellifera*) or the desert ant (*Cataglyphis bicolor)*. Navigation strategies in social insects are performed dominantly through path integration or 'dead reckoning' where the animals keep track of the distance and direction of their current position from the past trajectory and return back to their nest without retracing the steps of the outward journey, but rather take a direct path or straight routes (Möller and Wehner 1988; Rodrigo 2002). In the last decades a social insect desert ant became an ideal study model for (biological) autonomous agents in navigation. Passing on the knowledge of a feeding site to a nest mate would not contribute to the colony's success. On the other hand, each ant that can be found outside the nest follows the same of searching for food and then safely and quickly navigating home.

2.3 Basic mechanisms and orientation in biological navigation systems

Vector navigation includes direction and distance of journey from nest/ hive to food source. Some researchers monitor the energy or time spent to cover a certain distance. Many day-active arthropods, such as ants, honeybees and spiders, use the polarization pattern from the sun as a compass cue when returning to their nests (Waterman 1981; Wehner and Labhart 2006). Insect vision occurs through a pair of compound eyes on both sides of the head and three single-lens eyes, known as ocelli, that exist between the compounded eyes on the head. In many insects the perception of polarized light is mediated by anatomically and physiologically specialized ommatidia situated in the dorsal rim area of the compound eyes (Labhart 1986) and specifically detect the overhead e-vector pattern (Homberg 2004; Labhart and Meyer 2002; Wehner and Labhart 2006). A single ommatidium of a desert ant is shown in Figure 1a. The microvilli photoreceptors are well aligned along the rhadomere and oriented orthogonally to each other (R1, 5 *vs.* R2, 4, 6, 8 see Figure 1b).

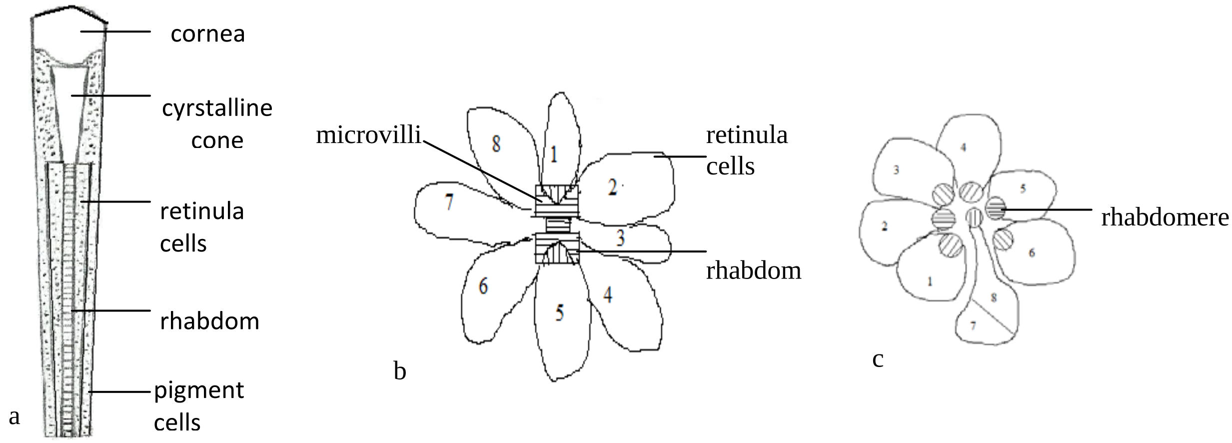

Figure 1: a) Single ommatidium of a desert ant. b) Cross section of an ommatidium of a desert ant, showing the orientation of the microvilli (R1, 5 are orthogonal with R2, 3, 4, 6, 7 8) and the rhabdom (dumb-bell shape and fused rhabdom) (image adapted from (Nilsson, Labhart, and Meyer 1987; Labhart and Meyer 1999). c) Cross section of flies having an open rhabdom in which six are in the outer and two in the central rhabdomeres. The central rhabdomere of retinula cells 7 and 8, which lie on top of one another (Manzel and Snyder 1983).

2.4 Architecture or behaviour of navigation

The organization of animal navigational performance can be described and explained. The correct information about directions and distances either in path integrator or the landmark-guidance routines are described in ants as shown in Figure 2. Path integration or vector navigation is a process where the animal keeps track of its direction and distance from a starting point (nest/hive) (Wehner 2009). Central place foragers such as honeybees, desert ants and many other hymenoptera make repeated foraging excursions and return back home safely each time (Wehner 2009; Srinivasan 2011; Wehner 2009). When *Cataglyphis* can access both polarization compass and sun compass, they tend to choose the polarization compass (Wehner and Müller 2006). Many animals use the sun as a compass or the skylight polarization pattern produced by scattering of the sunlight in the atmosphere (Wehner 1997). The skylight compass is based on the azimuthal position of the sun and the pattern of polarized light (e-vector pattern) (Wehner, Michel, and Antonsen 1996) and the polarization is at its most intense at a 90° angle from the sun. The odometer measured of travelling distances. Measured travelling distances in path integration are difference between desert ants and honeybees. In honeybees, they use optic flow (pattern of apparent motion) during the flight experience. While the desert ants measured of travelling distance using proprioreceptive (ability to sense stimuli arising within the body regarding position, motion and equilibrium) cues (Labhart and Meyer 2002). In honeybees, the primary cue of distance estimation is self-induced optic flow. Flight distance is not perceived in absolute units but as the total amount of image motion experienced during flight time (Esch and Burns 1995); (Srinivasan et al. 2000). In community odometer, the worker honeybee communicate the location of a nectar source to their hive mates by the waggle dance which the duration period of one waggle is longer indicate the goal are further (Dyer 2002). Insect optomotor system is critically dependent on image speed (Srinivasan, Poteser, and Kral 1999).

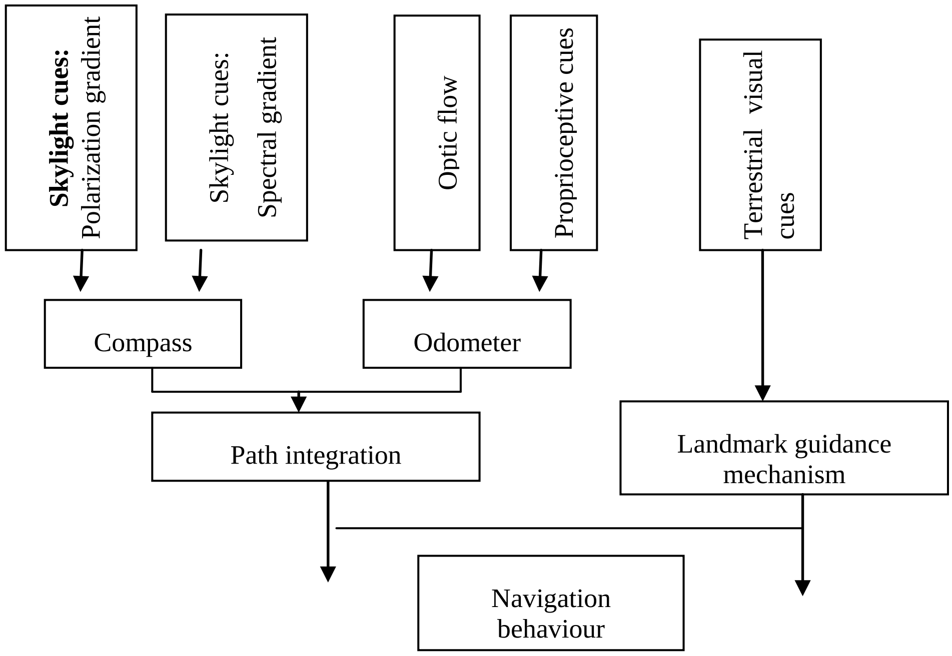

Figure 2: Schematic architecture of insect's navigation system. In path integration includes compass (external stimulus: skylight cues polarization gradient/ pattern and spectral gradient) and odometer (internal- optic flow mostly in honeybees and propriceptive in ants). The landmark-guidance modules include terrestrial cues (e.g view-based image matching, flow-field detection, and beacon aiming. The network and association to generate efficiency and successful navigation (adaptation from Wehner 2009)

3 Bio-inspired development

Biology is prepared for technology and engineering to develop device for human instrument. Conversion theoretical from biology to technology can be realized in many ways such as algorithms, simulation and modeling and mathematically. The animal kingdom are always become a great source of inspiration for the development of new and innovative navigation systems. Neuron in insect such as dragonflies are found in optic lobe (part of brain) that response nicely sensitive to small, dark and moving target regardless the motion of surrounding background. Recently, researcher applied the navigation system in desert ants to robot (Lambrinos et al. 2000); (Lambrinos 2003); (Srinivasan 2011). In the ongoing attempt to meet the engineering challenges of the present and future, systems science has often looked to biology for examples of what is possible and clues as to how it might be achieved (Hristu-Varsakelist and Shaof 2004). The implementation some of great gained from research of vision and navigation in insect to the guidance a device. Lambrinos et al. (2000) have done insect-inspired polarization compass to autonomous robots are called "Sahabot" (Sahabot - a terrestrial robot steered by polarization compass). Nowadays, the human navigation technology for navigation system is Global Positioning System (GPS). This system working where a receivers use a code to determine distances to each satellite and calculate their position and altitude (Cox and Vreysen 2005). However, GPS cannot currently perform in indoor and highly urban locations.

4 Outlook and Discussion:

Researchers are proposed models of honeybee map and navigation process vary from one extreme to other. Although navigation capabilities of insect are well known but little neural mechanism they use to perform that navigation. A growing number approaches in robotics get inspiration from the navigation capabilities that insects show despite diminutive brains (Möller and Wehner 1988). In future technologies inspired Microelectromechanical System (MEMS) can be developed to enhance, to assist and expand human sensory system.

References

Brower, L. P. 1996. Monarch butterfly orientation: Missing pieces of a magnificent puzzle. *J. Exp. Biol.* 199:93-103.

Collet, T. S. 2008. Insect navigation: Visual panoramas and the sky compass. *Curr Biol* 18 (22):R1058-R1061.

Cox, J. St. H., and M. J. B. Vreysen. 2005. Use of geographic information systems and spatial analysis in area-wide integrated pest management programmes that integrate the sterile insect technique. In *Sterile Insect Technique Principles and Practice in Area-Wide Integrated Pest Management*, edited by V. A. Dyck, J. Hendrichs and A. S. Robinson. Netherlands: springer.

Cruse, H., and R. Wehner. 2011. No need for a cognitive map: Decentralized memory for insect navigation. *PLoS Comput Biol* 7 (3):e1002009.

Dyer, F. C. 2002. The biology of dance language. *Annu. Rev. Entomol.* 47:917-949.

Esch, H. E., and J. E. Burns. 1995. Honeybees use optic flow to measure the distance of a food source. *Naturwissenschaften* 82:38-40.

Gallistel, C. R. 1990. *The Organization of Behaviour*. New York: Wiley.

Gebeshuber, I. C., B. Y. Majlis, and H. Stachelberger. 2009. Tribology in biology: biomimetic studies acrossdimensions and across fields. *Internatinal Journal of Mechanical and Materials Engineering* 4 (3):321-327.

Homberg, U. 2004. In search of the sky compass in the insect brain. *Naturwissenschaften* 91 (5):199-208.

Labhart, T. 1986. The electrophysiology of photoreceptors in different eye regions of the desert ant, Cataglyphis bicolor. *J Comp Physiol [A]* 158:1-7.

Labhart, T., and E. P. Meyer. 2002. Neural mechanisms in insect navigation: polarization compass and odometer. *Current Opinion in Neurobiology* 12 (6):707-714.

Labhart, T., and E.P. Meyer. 1999. Detectors for polarized skylight in insects: a survey of ommatidial specializations in the dorsal rim area of the compound eye. *Microsc Res Tech* 47 (368-379).

Labhart, T., and E.P. Meyer. 2002. Neural mechanisms in insect navigation: polarization compass and odometer. *Cur Opin Neurobiol* 12:707-714.

Lambrinos, D. 2003. Navigation in desert ants: the robotic solution. *Robotica* 21:407-426.

Lambrinos, D., R. Möller, T. Labhart, R. Pfeifer, and R. Wehner. 2000. A mobile robot employing insect strategies for navigation. *Robotics and Autonomous Systems* 30:39-64.

Mallot, H. A., and M. O. Franz. 1999. Biological approaches to spatial representation - A survey. *Robotics and Autonomous Systems* 65.

Manzel, R., and A. W. Snyder. 1983. Photoreceptor optics-structure and function of photoreceptor. In *Biophysic*, edited by W. L. W. Hopper, H. Markl and H. Ziegler. Berlin: Springer-Verlag

Merkle, T., and R. Wehner. 2010. Desert ants use foraging distance to adapt the nest search to the uncertainty of the path integrator. *Behavioral Ecology* Advance Access publication 27 January 2010.

Milford, M. J. 2008. Robot Navigation From Nature. *STAR* 41:29-39.

Möller, M., and R. Wehner. 1988. Path integration in desert ants, *Cataglyphis fortis*. *Proc. Nati. Acad. Sci. USA* Vol. 85:5287-5290.

Nilsson, D. E., T. Labhart, and E. P. Meyer. 1987. Photoreceptor design and optical properties affecting polarization sensitivity in ants and crickets. *J Comp Physiol A* 161:645-658.

Reppert, S. M., Robert J. Gegear, and C. Merlin. 2010. Navigational mechanisms of migrating monarch butterflies. *Trends in Neurosciences* 33 (9):399-406.

Rodrigo, T. 2002. Navigational strategies and models. *Psicológica* 23:3-32.

Srinivasan, M. V. 2011. Visual control of navigation in insects and its relevance for robotics. *Current Opinion in Neurobiology* 21:535-543.

Srinivasan, M. V., M. Poteser, and K. Kral. 1999. Motion detection in insect orientation and navigation. *vision Res* 39:2749-2766.

Srinivasan, M.V., Zhang S., Altwein M., and Tautz J. 2000. Honeybee navigation: nature and calibration of the "odometer". *Science* 287:851-853.

Stalleicken, J., T. Labhart, and H. Mouritsen. 2005. Physiological characterization of the compound eye in monarch butterflies with focus on the dorsal rim area. *Journal of Comparative Physiology A* 192 (3):321-331.

Vincent, J. F. V., O. A. Bogatyreva, N. R. Bogatyreva, A. Bowyer, and A. Pahl. 2006. Biomimetics: its practice and theory. *J. R. Soc. Interface* 3:471-482.

Waterman, T. H. 1981. Polarization sensitivity. In *Handbook of sensory physiology*, edited by A. H. Springer: Heidelberg.

Wehner, R. 1997. The ant’s celestial compass system: spectral and polarization channels. In *In Orientation and Communication in Arthropods*, edited by M. Lehrer. Basel, Switzerland: Birkhäuser.

Wehner, R. 2009. The architecture of the desert ant's navigational toolkit (Hymenopter: Formicidae). *Myrmecological News* 12:85-96.

Wehner, R. 2003. Desert ant navigation: how miniature brains solve complex tasks. *J. Comp. Physiol. A* 189:579-588.

Wehner, R., and T. Labhart. 2006. Polarization vision. In *Invertebrate vision*, edited by W. EJ and N. D-E. Cambridge,: Cambridge University Press.

Wehner, R., B. Michel, and P. Antonsen. 1996. Visual navigation in insects: coupling of egocentric and geocentric information. *J Exp Biol* 199:129-140.

Wehner, R., and M. Müller. 2006. The significance of direct sunlight and polarized skylight in the ant’s celestial system of navigation. *PNAS* 103 (33):12575-12579.

Wolf, H. 2011. Odometry and insect navigation. *The Journal of Experimental Biology* , 214:1629-1641.

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Networking Implications for Students, Alumni and Young Researchers

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ABSTRACT

Networking is of increasing importance in our professional lives.This workshop addresses the science and art of networking, introduces the philosophy of successful networkers, shares basics of how to tie networks and introduces successful networks, yesterday, today and tomorrow. As the last topic, the differences between current networks for women and networks for men are treated. The workshop comprises a slide presentation combined with practical exercises with active student participation, and provides the attendees with a toolbox of proven approaches for successful networking.

It is important what you know.

But it is also important whom you know

– And who knows about you.