Research article

Sensing in nature: using biomimetics for design of sensors

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Abstract
Purpose – The purpose of this paper is to illustrate how biomimetics can be applied in sensor design. Biomimetics is an engineering discipline that uses nature as an inspiration source for generating ideas for how to solve engineering problems. The paper reviews a number of biomimetic studies of sense organs in animals and illustrates how a formal search method developed at University of Toronto can be applied to sensor design.
Design/methodology/approach – Using biomimetics involves a search for relevant cases, a proper analysis of the biological solutions, identification of design principles and design of the desired artefact. The present search method is based on formulation of relevant keywords and search for occurrences in a standard university biology textbook. Most often a simple formulation of keywords and a following search is not enough to generate a sufficient amount of useful ideas or the search gives too many results. This is handled by a more advanced search strategy where the search is either widened or it is focused further mainly using biological synonyms.
Findings – A major problem in biomimetic design is finding the relevant analogies to actual design tasks in nature.
Research limitations/implications – Biomimetics can be a challenge to engineers due to the terminology from another scientific discipline.
Practical implications – Using a formalised search method is a way of solving the problem of finding the relevant biological analogies.
Originality/value – The paper is of value as most present biomimetic research is focused on the understanding of biological phenomena and does not have as much focus on the engineering design challenges.

Keywords Sensors, Sense organs, Sensory perception, Biology

Paper type Research paper

Biomimetics

Man has always been fascinated by nature and intrigued by the many genius ways that everyday problems are handled and solved. Functionality in many of the tools and artefacts that we use in our daily life can be traced back to origins in nature. The terms bionics, bionik (german) and biomimetics, however, are of a much more recent date. They all designate a study involving copying, imitating and learning from nature. The terms are constructed from Greek "bios" meaning life, the suffix "in" meaning like and "mimeistai" meaning imitate. Some dictionaries describe the term bionics as constructed from "biology" and "electronics". There are excellent books on biomimetics highlighting both its history and many interesting examples (Bar-Cohen, 2006; Nachtigall, 2002; Kato and Kamimura, 2007).

There is only a very limited correlation between the principles used to solve problems in technical artefacts and in biological systems. Vincent *et al.* (2006) have used the Russian TRIZ-method to show that there is only 12 per cent similarity between biology and technology domains in the principles that bind solutions to problems. This indicates a wealth of inspiration in nature for how to solve technical problems.

Bonser and Vincent (2007) has counted the number of "biology-inspired" patents and found that it has gone from 0 to 1,200 in the last 20 years.

It is possible to directly copy solutions from nature, but for engineering purposes it is often more useful to use nature as inspiration source. Hesselbjerg (2007) describes how this can be done to various degree of sophistication from the study of a single function as for example the self cleaning lotus flower to the study of more complex organisms involving several functions. An example of this is the ragworm – a marine creature that gives inspiration for how to move in slippery substrates and the design of novel endoscopes (Hesselbjerg, 2007) – see Figure 1.

Bleckmann *et al.* (2004) looks at infrared organs in Bupestrid beetles and snakes and on electrolocation used by nocturnal fish. The beetles have infrared organs that can detect forest fires on a distance of many kilometres. The infrared light has a wavelength between 2.2 and 4 μm which travels well through the atmosphere. The reason for seeking the burned areas is that

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