

Generalizing the Biomimetic Design Process

L.H. Shu, Associate Professor
Dept. of Mechanical & Industrial Engineering, University of Toronto
shu@mie.utoronto.ca

Abstract

While many elegant solutions to engineering problems have been inspired by biological phenomena, it is not always clear how the particular biological phenomena were selected. The objective of this work is to develop a generalized methodology by which analogous biological phenomena can be identified and used for any design problem in a systematic manner. The chosen approach has been implemented in a computer search tool that locates in a biology text, instances of functional keywords describing the engineering problem. Analogies for case studies in design for remanufacture and microassembly as well as ongoing work will be summarized.

1. Introduction

There are many elegant solutions to engineering problems that were inspired by biological phenomena. Most work in biomimetic design involves specific cases of design that copy particular biological models. For example, topics submitted to this symposium include robots modeled after insects and other organisms, and leaves serving as models for antennas and vascular networks. Biological models are also used to develop novel materials, actuators and sensors, some for prosthetic or implant applications. However, not always described is how particular biological models were identified or selected. Therefore, an engineer open to using biological models for design may not know how to find relevant biological analogies for a given design.

This paper will summarize our past and current work towards developing an approach to identify and use relevant biological analogies for any given engineering problem. Analogies identified using this approach for case studies in design for remanufacture and microassembly will be described. Finally discussed will be ongoing challenges and work towards overcoming these challenges.

2. Methods

The goal of this work is to develop a generalized methodology by which analogous biological phenomena can be identified and used for any engineering design problem in an objective and repeatable manner. One possible approach to enable generalized biomimetic design is to build a database of biological phenomena for engineering use (Vincent and Mann, 2002). The approach described here is fundamentally different and avoids the enormous and possibly subjective task of cataloguing biological phenomena for engineering. Instead, this method takes advantage of the abundant biological information already available in natural language format by searching it directly for relevant phenomena.

This approach has been implemented in the form of a computerized search tool that locates in biology texts, instances of functional keywords describing the engineering design problem.

a. Source

The initial source of information selected is *Life, the Science of Biology* (Purves et al., 2001), which is the reference text for the introductory course in biology at the University of Toronto. This text is suitable because it is written at a level that can be easily understood by those with little background in biology. Also, the text covers a large range of organizational levels, from the molecular and cellular, e.g., DNA, to the ecosystem, such that potential solutions are not limited to a particular organizational level.

b. Keywords

Keywords used to search for relevant text segments are verbs that describe the desired effect of possible solutions. Verbs are strongly preferred over nouns as keywords to initiate searches. Searching for nouns typically indicates pre-conceived solutions while searching for verbs that describe the desired action will identify biological forms that may not have occurred to the designer.