Using Biological Analogies for Engineering Problem Solving and Design

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Abstract

This paper summarizes various aspects of identifying and using biological analogies in engineering design. To avoid the immense as well as potentially biased task of creating a database specifically for this purpose, the chosen approach searches biological knowledge in natural language format, e.g., books, papers, etc., for instances of functional keywords describing the engineering problem. Strategies developed to facilitate this search as well how text descriptions of biological phenomena were used in problem solving are summarized. Case studies in design for remanufacture and microassembly are used to provide an overview of the method.

1. Introduction

Many elegant solutions to engineering problems have been inspired by biological phenomena. While most work in biomimetic design involve specific cases of design that copy particular biological models, not always described is how these biological models were identified or selected. Therefore, it is possible that 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 ongoing work in developing an approach to identify and use relevant biological analogies for any given engineering problem. First highlighted are ongoing challenges in natural language processing and analogical reasoning, and the work towards overcoming these challenges. Analogies identified using this approach for case studies in design for remanufacture and microassembly are then described to illustrate the process.

2. Method

The purpose 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 avoids the immense and likely 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 of biological information

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.

Other texts can be substituted or added as required for the initial search. The more challenging task is the initial identification of relevant phenomena. Further details on such phenomena can be easily found using more advanced texts and research papers.