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BRIDGING CROSS-DOMAIN TERMINOLOGY FOR BIOMIMETIC DESIGN

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ABSTRACT

This work aims to improve creativity and innovation in design by facilitating the use of cross-domain analogies, particularly from biological phenomena, as stimulus for concept generation. Rather than create an enormous database of biological knowledge to specifically support engineering design, we have chosen to take advantage of the large amount of biological knowledge already in natural-language format, e.g., books, journals, etc. Relevant biological analogies for any given design problem are found by searching for instances of functional keywords that describe the intended effect of the design solution in a natural-language corpus.

However, the optimal choice of keywords, or search terms, is complicated by the fact that engineers and biologists may use differing domain-specific lexicons to describe related concepts. Therefore, an engineer without sufficient background in biology may not be able to identify keywords with biological connotation that are not obviously related to the engineering keywords.

This paper describes efforts to bridge the gap in lexicons by examining words that frequently collocate with searched words. The biological meaningfulness of these bridge words is characterized by how frequently they occur within definitions of biological terms in a biology dictionary. Search words identified this way may not be obvious to domain novices, and may parallel those suggested by domain experts, thus facilitating the use of cross-domain ideas to support design.

Our approach of generating bridge words with biological meaningfulness is generic and can be used to bridge any disparate domains (e.g., engineering and economics). Thus designers are enabled to quickly access relevant concepts from different domains to produce more innovative solutions.

INTRODUCTION

Biomimetic design uses biological phenomena as inspiration for solutions to engineering problems. One well-known example of biomimetic design is the development of Velcro after observing that cockleburs attach to clothing and fur. Other work includes correlation of heat transfer principles to shapes found in nature to aid in optimization (Bejan, 2000). Benami and Jin (2002) note that analogies from conceptually different domains result in more creative, original ideas. In the development of synectics, Gordon (1961) observed that biology provided the richest source of direct analogies. The success of many biologically inspired designs also supports that biology is a good source of analogies. However, designers are generally limited by their personal knowledge of biology.

One approach to overcome this limitation is to create a database of biological phenomena organized by engineering function (Vincent & Mann, 2002; Lindemann & Gramann, 2004). However, compiling and updating a suitably expansive database is resource intensive and may be subject to the compilers' own knowledge and bias. This and other challenges of database incompleteness are recognized by the bioinformatics community struggling to keep up with an explosive growth of information (Rebholz-Schuhmann et al., 2005).

Our approach is to take advantage of the enormous amount of biological information already available in natural-language format, such as books, journals, etc. Instances of functional keywords are sought in the biological corpus, or body of text. Matches, or text excerpts containing keywords, are examined for relevant biological phenomena that can be applied towards the engineering problem. Our initial biological corpus is an introductory university-level textbook: *Life, the Science of Biology* (Purves et al., 2001). Verbs are used to formulate keywords because they convey functionality (Stone & Wood, 1999; Ullman, 2003) and are important to the interpretation of sentences (Joanis & Stevenson, 2003).

Past case studies using this method include those in design for remanufacture (Vakili & Shu, 2001; Hacco & Shu, 2002) and centering in microassembly (Shu et al., 2003). Fundamental work performed to improve this method includes