Proceedings of DETC '04
ASME 2004 Design Engineering Technical Conferences and Computers and Information in Engineering Conference
September 28-October 2, 2004, Salt Lake City, Utah USA

DETC2004-57250

NATURAL LANGUAGE ANALYSIS FOR BIOMIMETIC DESIGN

I. Chiu and L.H. Shu*

Department of Mechanical and Industrial Engineering
University of Toronto
5 King's College Road, Toronto, Ontario M5S 3G8 Canada
*shu@mie.utoronto.ca

ABSTRACT

Biomimetic design uses ideas from biological phenomena as inspiration in design. To support biomimetic design, biological analogies are identified by finding instances of functional keywords that describe the engineering problem in biological knowledge in natural-language format. Challenges in using this approach include the identification of keywords, and the quantity and quality of results found.

WordNet, a lexical database, is used as a language framework to systematically generate alternative keywords to find matches and analyze the results of searches. Troponyms from WordNet were found to provide better and more plentiful keywords than did synonyms.

Due to the potentially large number of matches to keywords, matches are analyzed to facilitate extraction of dominant biological phenomena associated with keywords. This analysis found that words that frequently collocated with keywords tend to be objects of the keyword verb or agents that carry out the actions of the keyword. Furthermore, nouns that are inanimate, e.g., substances, tend to be objects, and nouns that are animate e.g., animals, organs, tend to be agents. Distinguishing frequently collocated words and their relationships to keywords can be used to facilitate identification of biological analogies in natural-language format to support design.

1 INTRODUCTION

Biomimetic design uses ideas from biological phenomena to inspire design concepts. Many examples of biomimetic design exist, the most often cited of which is the development of Velcro after observation of how plant burrs stick to materials such as clothing and fur. Most instances of biomimetic design occur following observation of an interesting biological phenomenon or were inspired from a biological phenomenon already known to the designer. We believe that a systematic search of biological phenomena relevant to a particular design problem will identify a greater variety of potential analogies, and likely result in more creative design than depending on chance knowledge of biological phenomena.

One approach to support a systematic biomimetic design process would be to create a database of biological phenomena relevant to engineering (Vincent and Mann, 2002). However, not only is the task of creating and updating such an immense database significant, but the assignment of biological phenomena to engineering categories is a subjective process that may reduce the richness of the original information.

Our approach to support biomimetic design is to directly search the vast amount of biological knowledge already available in natural-language format. Previous work using this approach, described by Vakili and Shu (2001), Hacco and Shu (2002), and Shu et al. (2003) searches for instances of keywords and their synonyms in a biology text, *Life, the Science of Biology* (Purves et al., 2001).

A search to support biomimetic design imposes additional challenges beyond simply searching by topic, since the relevance of potentially analogous information across disciplines, or between domains, is more difficult to determine than the relevance of direct information on a specific topic.

2 MOTIVATION

Several difficulties common to natural-language processing occurred during previous work, from the identification of suitable keywords, to the quality and quantity of matches that result. These difficulties serve as motivation for the work reported in this paper.

2.1 Identification of appropriate keywords

Keywords that describe the engineering problem may be used neither in a biological context nor in everyday speech. Therefore, alternative keywords are required to increase the chance of finding relevant results. Previous work used synonyms as additional keywords. However, the relationship between the original keyword and synonyms identified from a thesaurus is not always clear.