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SUPPORTING BIOMIMETIC DESIGN THROUGH CATEGORIZATION OF NATURAL-LANGUAGE KEYWORD-SEARCH RESULTS

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ABSTRACT

Biology is a good source of analogies for engineering design. One approach of retrieving biological analogies is to perform keyword searches on natural-language sources such as books, journals, etc. A challenge of retrieving information from natural-language sources is the potential requirement to process a large number of search results. This paper describes a categorization method that organizes a large group of diverse biological information into meaningful categories. The benefits of the categorization functionality are demonstrated through a case study on the redesign of a fuel cell bipolar plate. In this case study, our categorization method reduced the effort to systematically identify biological phenomena by up to ~80%.

INTRODUCTION

Analogies from conceptually different domains have been observed to result in more creative design solutions (Benami & Jin, 2002). Gordon (1961) noted that the specific domain of biology provides the richest source of direct analogies. Many successful biomimetic designs support the notion that biology is a good source of analogies. Despite the demonstrated usefulness of biological analogies in design, designers are likely limited by their personal knowledge of biology. Linsey et al. (2007) also support that designers require tools and systematic methods to access cross-domain knowledge.

Two main approaches exist for biological knowledge retrieval. One approach to support biomimetic design is to create a database of biological phenomena organized by engineering function (Vincent & Mann, 2002; Lindemann & Gramann, 2004). However, the creation of such a resource may be both time consuming and resource intensive. The process may also be subject to the compilers' own knowledge and bias. Additionally, the rapid growth of biological knowledge provides further challenges for the updating of such a system (Rebholz-Schuhmann et al., 2005; Spasic et al., 2003).

Another approach to support biomimetic design involves searching for instances of functional keywords in biology knowledge sources in natural-language format, e.g., books, papers, etc. Matched text excerpts containing keywords are examined for relevant biological phenomena that can be applied to the engineering problem of interest. This method takes advantage of the extensive biological information already existing in natural-language format. A method was developed to use word collocation and frequency analyses to identify biologically meaningful keywords that bridge the different lexicons in the fields of biology and engineering (Chiu & Shu, 2007). Cheong et al. (2008) translated terms of the Functional Basis into biologically meaningful keywords, not obviously related to the functional keywords, to use as search keywords.

However, a shortcoming of searching natural-language text using keywords is the large number of matches that may result. Therefore, the designer may need to process a large amount of information to identify the most suitable analogies.

NOMENCLATURE

Search Related

Data Mining: Process of extracting patterns from a collection of data.
Corpus (plural: Corpora): A large structured set of text. The corpus on which the biomimetic search tool performs is *Life, the Science of Biology* (Purves et al., 2001).
Match Excerpt: One or two sentences surrounding the search keyword in a section.
Section: A logically divided group of words from the corpus.
WordNet: A lexical database that organizes words according to their relationships to each other (WordNet, 2006).
Stop Words: A list of commonly occurring words disregarded during searches, e.g., the, for, etc.