Biomimetics Applied to Centering in Microassembly

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Abstract
This paper describes the application of a biomimetic search method to develop ideas for centering objects in microassembly. Biomimetics involves the imitation of biological phenomena to solve problems. An obstacle to the use of biomimetics in engineering is knowledge of biological phenomena that are relevant to the problem at hand. The method described here starts with an engineering problem, and then systematically searches for analogous biological phenomena using functional keywords. This method is illustrated by finding and using analogies for the problem of positioning and centering objects during microassembly. Relevant phenomena identified involve microtubule organizing centers, photosystems, and retinal ganglion cells.

Keywords:
Design methodology, Microassembly, Positioning

1 INTRODUCTION

Biomimetic design uses biological phenomena to inspire solutions for engineering problems. While many examples of biomimetic design exist, not yet available is a generalized method by which one can find relevant biological analogies for a given engineering problem. Some examples of biomimetic design originated from interesting biological phenomena, and were subsequently developed into engineered products. For example, Velcro hook and loop fasteners were invented after observation of how plant burrs attached to materials such as clothing and animal fur. Other examples of biomimetic design copy fairly obvious examples, e.g., flying machines modeled after birds, underwater machines modeled after fishes, and robotic grippers modeled after the human hand. In other cases, how the biological model was identified and selected is not clear. Therefore, to make biomimetic design more accessible to engineers, required is a generalized method by which one can identify relevant biological analogies for a given engineering problem in an objective and repeatable manner.

Such a method has been introduced in earlier work, and will be summarized here before describing the current problem in microassembly. Next, the results of searching for phenomena relevant to the selected problem will be presented, including the potential strategies and solutions that may be derived from these biological phenomena.

2 BACKGROUND ON BIOMIMETICS

2.1 Related work

Numerous examples of biomimetic design have been documented in various forums. Those described in CIRP Annals include the work of Ueda *et al.,* who developed the concept of Biological Manufacturing Systems (BMS) to deal with unpredictable changes in external and internal environments of manufacturing systems based on biologically inspired ideas [1-3]. Specifically, evolution-based and self-organization models of manufacturing systems were developed that can cope with environmental changes such as system reconfiguration, machine breakdown and unforeseen production requests. Also described are reinforcement learning approaches for the modeling of BMS [3].

2.2 Previous work

A biomimetic search tool was developed that locates in biological knowledge in natural-language format occurrences of keywords describing the engineering problem. While difficulties common to natural-language processing occurred, this approach does not require the tremendous and somewhat subjective task of categorizing all biological phenomena by engineering function. Thus this approach can readily take advantage of the enormous amount of biological knowledge already in natural-language format. A previous application problem involved finding and using biological analogies in design for remanufacture [4-5].

Source of Biological Information

The initial source of biological information, *Life, the Science of Biology* [6], is the reference text for the introductory course in biology at the University of Toronto, and is suitable here for two reasons. First, the book is at a level that is easily understood by those who have little or no background in biology. Second, the book is general and covers several levels of biological organization, from the molecular (e.g., DNA) to the ecosystem level. An electronic copy of the text was obtained and a search tool developed that looks for occurrences of functional words describing the engineering problem within the text. As reported previously, this initial source may not give enough details to inspire a novel solution, but is useful for identifying relevant phenomena that can then be further researched in more advanced sources [4]. More specific texts used to find details on relevant phenomena include those on molecular and cell biology, plant physiology and animal physiology [7-9].