

Using Templates for Defensive Wall Building with Autonomous Mobile Ant-Like Robots

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Abstract. This paper reports on the preliminary findings of the application of collective minimalist robotics to the task of wall building. Studies on social insects, such as ants, reveal that construction of complex nest structures are built by animals with no internal ‘blue-print’ of the global structure. Such structures emerge as the consequence of the interactions of the insects, carrying out simple behaviours, and the environment. In particular, the exploitation of heterogeneities, referred to as templates, is investigated. Such a biological paradigm involving simple ‘agents’ limited in their capacity for computation, communication and sensing has an obvious appeal to those researching into minimalist collective robotics. The underpinning biological mechanisms may be of particular importance when building very small robots where computation, sensing and ability to communicate may be seriously constrained. This paper shows how linear structures, composed of circular objects, can be formed by a group of simple mobile robots without recourse to direct communication, sophisticated sensing or intensive computation.

1. Introduction

It has been argued that engineers like to make systems with certain characteristics such as, use of simple components, use of many identical modules; reliability of system operation, adaptability to environmental changes; and robustness with respect to component failures [Holland & Melhuish 1996]. Social insects, such as ants, arguably provide an existence proof of minimalist collective control mechanisms which employ decentralized control, self-organization, redundancy and stigmergy which is a form of indirect communication through the environment [Melhuish *et al* 1998].

This paper develops the idea that these minimalist collective characteristics could be interesting to engineers engaged in designing and building multiple robot systems. Inspired by nest construction behaviour in ants [Franks & Deneubourg 1997] this study explores simple wall building by a group of many simple robots. In particular, attention is focused on the use of environmental heterogeneities or discontinuities, referred to as templates, in the environment. For this study no robot holds an internal representation of the task in terms of a world model [Brooks 1991]. The task is achieved as the emergent consequence of the robots executing simple reactive rules triggered by local conditions.

The paper is organised as follows. Section 2 introduces the nature of environmental templates and how they might be used by natural collective systems such as ants in wall building. Section 3 describes the material and methods used for the experiment discussed in section 4. The results presented in section 4 are discussed in section 5.

2. Background and Motivation

2.1 Templates

The motivation for the study comes from observations of wall building in natural social insect systems and the exploitation of heterogeneities or ‘templates’ in the environment. Many ant species such as *Myrmica rubra* [Thome 1972] make use of temperature and humidity gradients when building nests and distributing their eggs, larvae and pupae. Theralauz *et al* [1998] state that the behaviour of most insects is influenced by heterogeneities in the environment. They define a template as a heterogeneity which is a perceptible (by the insects) deviation from a uniform distribution or constant quantity. Thus predictably varying quantities such as varying light levels, chemical concentration gradients and soil levels can be included. Thus the insects’