Exploiting Domain Physics: Using Stigmergy to Control Cluster Building with Real Robots

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Abstract. This paper explores the application of stigmergy as a mechanism for the control and coordination of cluster building with 10 simple, autonomous, mobile real robots. Social insects collectively carry out extraordinary tasks using simple reactive rule sets with little or no memory and without recourse to internal world models over which they reason. Control and coordination of behaviour can be mediated externally through the environment. In particular, building tasks may employ the configuration of each construction phase to cue the next phase. This paper shows how, using physical robots, the deterministic clustering algorithm of Beckers *et al* [1994] can be modified to create a cluster of objects against the arena wall. The modification takes the form of either applying probabilistic rule selection or by altering the robot sensor morphology. These two approaches illustrate that equivalent qualitative emergent consequences can be generated algorithmically or by exploiting the domain physics.

1 Introduction

Social insects, such as ants, provide an existence proof of minimalist collective control mechanisms. They exhibit characteristics such as, decentralized control, self-organization, redundancy and indirect communication through the environment (stigmergy). This paper develops the idea that these minimalist collective characteristics could be attractive to engineers in the design and implementation of multiple robots. For example, such mechanisms may prove to be usable by designers of milli and micro-scaled robots. At such scales there may be considerable limitations on communication, sensing, mobility, computatation as well as power. It makes sense therefore to consider if there are exploitable characteristics arising from the tight coupling between the environment and the action repertoire of embodied agents. In particular this study explores collective building activity of many simple robots where the global task achieving behaviour is not explicitly represented, that is, no robot has an internal representation of the task. The task is achieved as the emergent consequence of the robots executing simple reactive rules triggered by local conditions. In this context the paper focuses on how stigmergy can be employed to