Abstract

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Dispersion and Exploration of Robots on Graph Topology and Computational Power of Robots from Visibility Perspective

A considerable amount of research has been devoted in recent years to the study of distributed algorithms for autonomous multi-robot system. A multi-robot system, which are collectively referred to as *robot swarms* consists of a set of autonomous mobile computational entities, called *robots*, that coordinate with each other to achieve some well defined goals, such as forming a given pattern, exploration of unknown environments etc. In this thesis we study two interesting problems DISPERSION and EXPLORATION and also study the influence of power of *Visibility* on the computational capability of a robot.

The subject matter of this thesis can be interpreted from two broad perspectives. The first is solving a particular problem with minimum number of assumptions, and finding the optimal value of various parameters with which the problems can be solved. The second is investigating, what affect does various capabilities such as memory, communication, synchronicity have on the problem solving capacity of a robot swarm. Pertaining to the first perspective, in our thesis, we solve the problem of DISPERSION in an arbitrary graph with optimal memory, and we solve the problem of EXPLORATION in dynamic ring, by removing the assumption of landmark node, with minimum number of robots. Pertaining to the second perspective, in our thesis, we investigate what affect variation in the power or capability of *visibility* have on the computational capability of a robot swarm. Here, we also investigate the relation between the capabilities of *visibility* and *synchronicity* and whether limitation in capability can be enhanced by strengthening another capability.

The DISPERSION problem asks $k \leq n$ robots, initially placed arbitrarily at the nodes of an n-node anonymous graph, to reposition themselves to reach a configuration in which each robot is at a distinct node of the graph. In Chapter 2, we study the DISPERSION problem on an arbitrary connected graph, where the robots are anonymous. Here, we consider that all the robots are located at the same node in the initial configuration. When the robots have identifiers, the leader election process which can be done deterministically, but in our case as the robots are anonymous we take the help of coin-tossing, i.e., the leader election process is probabilistic. We solve the problem with optimal amount of memory.

The EXPLORATION problem asks for a distributed algorithm that allows the robots to explore the graph, with the requirement that each node has to be visited by at least one robot. In Chapter 3, we consider the EXPLORATION problem, and to solve it in a dynamic ring without any landmark,i.e., any special node which can be distinguished from other nodes. In this chapter we assume the power of chirality, i.e., all the robots have a common clockwise and anticlockwise direction. We define another problem, MEETING and solve it in the presence of chirality as an essential step to solve the overall problem of EXPLORATION. In Chapter 4, we solve the same problem as Chapter 3 but by removing the assumption of chirality. This changes the whole scenario as solving the problem of MEETING becomes difficult without chirality. Therefore we have to define a new problem called CONTIGUOUS AGREEMENT to solve the problem of MEETING, and eventually EXPLORATION is solved.

Then in Chapter 5, we make a comparative analysis of what affect does variation in the *visibility* capability have on the compuatational capability of a robot swarm. Finally in Chapter 6, we discuss some directions for future research.

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