THESIS WORK

1-INTRODUCTION

In this thesis work, it is aimed to create a novel method for formation control of a swarm which consists of heterogenous mobile robots. The term of swarm represents a large group of locally interacting individuals with common goals[4].

Self organizing swarm researches and its applications are generally inspired by the biological systems in the nature.

The behaviours of these biological systems were considered mysterious and strange for a long time, but in recent researches show that individuals don't need any sophisticated knowledge or top level functionalities to produce such complex tasks[2] . These biological systems (e.g. colony of ants) have simple behaviours but they can accomplish very complicated collective tasks in the nature which are impossible with their own individual capabilities. Beni [1] describes this collaboration of members as follows:

The group of robots is not just a group. It has some special characteristics, which are found in swarms of insects, that is, decentralised control, lack of synchronisation, simple and (quasi) identical members.

It is obvious that such a collective behaviour of these swarms has more power and efficiency than the sum of the individual capabilities of the members.

General aspects of the swarm robotics systems are the simplicity of individuals, restricted sensing and communication capabilities, achieving tasks mutually, robustness and decentralized control capability[6].

In real world applications there may be need for different

functionalities to achieve some specific tasks. If this is the case, one solution may be to design a [sophisticated](http://www2.zargan.com/tr/q/sophisticated-ceviri-nedir/sophisticated-turkce-ne-demek) robot which includes all required capabilities for this task. In this scenario, this robot will be the single point of failure in the system and if robustness is a vital feature for this solution, some redundant robots have to be added to the system. It is clear that the design of such an advanced robot and hold its redundant backups in the system will increase the cost of the solution. In swarm robotics concept, another approach is to gather some different types of simple mobile robots which have their own specific functionalities to achieve a collective task rather than designing an advanced robot for the solution. With this approach, the robustness of the system is increased, costs are reduced down and the reusability of the individual members of the swarm for other tasks is provided.

Swarm robotics has been studied to produce different collective behaviors to solve tasks such as as aggregation , pattern formation , self-assembly and morphogenesis , object clustering, assembling and construction , collective search&rescue and exploration , coordinated motion , collective transportation , self-deployment , foraging and others[5]. Dorigo and Trianni[7] are studied on controllers for aggregation of coordinated motion of the identical mobile robots called swarm-bots. Hou, S.P., C.C. Cheah, and J.J.E. Slotine is focused on controlling of a swarm within a dynamically changing formation[8]. Ganesh and Lisa introduced two new strategies for collective search and exploration of fields with swarm intelligence[9]. Chaimowicz and Campos proposed a new methodology which is based on a dynamic role assignment mechanism in which the robots cooperate with each other and they demonstrate this method in a cooperative transportation task[10]. Campo and Gutierrez is studied on collective foraging task and they propose a method for path selection to optimize the profits of the swarm[11].

There are lots of studies related with different problems in swarm robotics literature as discussed briefly. In this thesis project, we are focused on pattern formation control of swarms consist of heterogeneous robots.

1-1 Motivation

The formation control problem can be defined as leading the individual agents of a swarm to perform a collective task while traversing a trajectory by providing collision avoidance simultaneosuly. It focuses on the large group of small and simple robots that can cooperate with each other. Formation control of multi agent systems is an actively growing research field.

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Potential applications for swarm robotics is indeed huge. It includes tasks that demand for [miniaturization](https://en.wikipedia.org/wiki/Miniaturization) ([nanorobotics](https://en.wikipedia.org/wiki/Nanorobotics), [microbotics](https://en.wikipedia.org/wiki/Microbotics)), like distributed sensing tasks in [micromachinery](https://en.wikipedia.org/wiki/Micromachinery) or the [human body](https://en.wikipedia.org/wiki/Human_body). One of the most promising uses of swarm robotics is in disaster rescue missions. Swarms of robots of different sizes could be sent to places rescue workers can't reach safely to detect the presence of life via infra-red sensors. On the other hand swarm robotics can be suited to tasks that demand cheap designs, for instance [mining](https://en.wikipedia.org/wiki/Mining) tasks or agricultural [foraging](https://en.wikipedia.org/wiki/Foraging) tasks. Also some artists use swarm robotic techniques to realize new forms of [interactive art](https://en.wikipedia.org/wiki/Interactive_art).[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

Much more controversial than the above-mentioned uses of Swarms, they can also be used in military to form an autonomous army of their own. Recently, the U.S. Naval forces have tested a swarm of autonomous boats that [[3]](https://en.wikipedia.org/wiki/Swarm_robotics" \l "cite_note-3) can steer and take offensive action by itself. The boats are unmanned and can be fitted with any kind of kit to deter and destroy enemy vessels.

Most efforts have focused on relatively small groups of machines. However, a swarm consisting of 1,024 individual robots was demonstrated by Harvard in 2014, the largest to date.[[4]](https://en.wikipedia.org/wiki/Swarm_robotics" \l "cite_note-4)