Chapter 1

Introduction

New progress in robotics have opened a new branch of studies. Taking inspiration from social animals like ants, bees or fishes, groups of robots are now able to perform tasks that could not be undertaken individually. These groups are called swarms. Applications related to these tasks have begun to flourish in the literature (e.g., search and rescue, environment exploration, oil spill cleaning). In swarm robotics system, each robot executes the same controller code. The interaction between the robots and between the robots and the environment enable the emergence of a collective behaviour. There is no hierarchy in the swarm. That is, all the robots behave autonomously. Research in swarm robotics is important as it underpins potential future disruptive innovations. Nanorobotics is going to be one of these innovations. The use of nanorobotics in medicine will grow over the next years. It could be one of the future solutions to cure cancer or other diseases by targeting the faulty constituents of the body with a swarm of very small robots.

Even though swarm robotics can carry out tasks autonomously, they do not have a global understanding of the environment and of the task that must be completed. A human operator can, therefore, interact with those swarm systems to issue them commands (i.e., what type of task to carry out and where to carry out the task). In that case there is thus a one-way communication between the human and the swam of robots. For swarm robotics to be adopted outside of research laboratories and tackle real world issues, one should always be able to take control of the swarm at any time. This is a legitimate safety requirement when considering the use of a large amount of robots around humans. Hence one can understand the vital aspect of the interaction between human and swarms of robots.

To date, little attention has been paid on the messages that are sent from the swarm to the human operator. Most of the research works focus on issuing commands to swarms. However, there might be situations in which the human doesn't know everything (i.e., where a gas leak comes from). In these situations, we can leverage swarm robotics systems to help humans move in dangerous environments. To the best of our knowledge, no study has considered a human being escorted by a swarm of robots in ~~such~~ a dangerous environment.

In this thesis we make an attempt to address this lack of consideration. We study how a swarm of robots can help a human move in dangerous environments. We use inspiration of flocking and pattern formation to allow a swarm of robots prevents a human from entering dangerous areas. These areas are invisible to the human and could contain mines, be radioactive or present another type of danger (e.g., poisonous gas, unstable floor). To avoid these areas, the swarm of robots escorts the human. There is a bidirectional feedback between the swarm and the human. The robots warn the human about the danger, and the human indirectly controls the position of the robots by changing his/her position. It contrasts with most of the studies that only contain a unidirectional feedback (the human controlling the swarm). For the robots to stay around the human, we had to find a way to make the human detectable for the robots. We built an entirely new portable device for that purpose.

Our solution went through a series of tests. The majority of the tests was used to incrementally improve the solution. These tests were made in a simulator and on real robots. At the end of the implementation, more tests were performed to assess the quality of the solution. Overall results are promising: the robots are following the human and warn him/her about near dangers.

This thesis is outlined as follows. In chapter 2 we present studies related to this master thesis. We introduce swarm robotics and provide some general insight in human - robots interaction, and human - robotic swarm. In chapter 3 we expose the problem we address in more details. We also provide a complete description of our solution. Chapter 4 contains detailed explanations on the tests we conducted. Finally we conclude ~~about~~ our work in chapter 5.