PhD THESIS ABSTRACT

„CONTRIBUTIONS TO THE DEVELOPMENT OF AN ELECTRICALLY DRIVEN ROBOT FOR OPERATIONS IN ROBOT SWARM"

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In the last period of time, we are all witnessing the development of autonomous robots, which can work in a collaborative system or even as robot swarms. The use of these systems is mainly due to the fact that autonomous robots can coordinate their operations and work together to perform a variety of tasks, which cannot be performed by a single robot, or be ineffective in doing so.

Robot swarms are new elements and their field of use is not well understood. The major problem with swarms at this point in the design is not having clear guidance about the mission of the swarm. Because of this, the hardware architectures of the actual systems have limited reusability, and the programming required to operate them inhibits the large-scale use of robot swarms.

The aim of the PhD thesis was to identify the optimal solution in terms of size, computing power, necessary sensors and communication system for realization, development and testing of a mobile robot that can be part of a swarm. The swarm's mission is to map an unknown area. At first, we have created, developed and implemented an image processing algorithm to map the area around the robot. Matching images are captured using a omnidirectional system consisting of a video camera and a spherical mirror on an obstacle course. Based on the data from the odometry sensors, the image processing algorithm has to determine a relative position of the obstacles and through the communication system to transmit the positions of the encountered obstacles to other robots in the swarm.

Based on the study of other robot swarm architectures, a platform, called NEXUS 2, was made to carry out the mapping of an unknown area. The hardware part of the robot consists in designing and making a double-layer PCB on which are found: the robot's power system, the sensor system for determining the odometry of the robot, the computing system and the communication system. Also, the robotic platform uses Raspberry Pi 3B+/ Jetson Nano as the main computing system and an omnidirectional image capture system.

For the development of the software part, were initially carried out simulations of the image processing algorithms and the simulation of the approximation of obstacles with ellipses. These simulations were made using MATLAB software. For image processing algorithm, a set of images was made using an omnidirectional system consisting of a web camera and a spherical mirror on a set path with obstacles. The aim of the simulation was to identify an algorithm that would create a map in real coordinates of the obstacles present in the scene. The error approximation of the obstacles consists in approximating the contour of obstacles with ellipses. For this determination, a route identical to the one used in the simulation of the image processing algorithms was used. The purpose of this simulation was to identify the solution to minimize the amount of data that needs to be transmitted to the other robots in the swarm.

Finally, to test the proposed solutions, a series of real tests were carried out. First of all, the sensors for determining the robot's odometry were simultaneously tested, with the aim of determining their error. To know the real movement of the robot all the tests were performed in an arena with graph paper. Next, the tests of the image processing algorithm were carried out, by adapting the code from MATLAB to Python and running it on Raspberry Pi 3B+ and it was determined that the system cannot perform real-time processing. Because of this, a process of optimization of the algorithm was started, which led to the replacement of the Raspberry Pi 3B+ with the Jetson Nano. After the optimization was completed, real map approximation tests and obstacle coordinate transmission using Jetson Nano were performed.