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Assistant Robot for Gait Rehabilitation in People with Disability

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Abstract

The aim of this work has been the programming of a low-cost mobile robot that acts as a complementary tool in the therapeutic sessions of gait rehabilitation for people with physical and cognitive disabilities. The robot has an assistive function, being able to guide, accompany and motivate the person during the completion of a route previously designed by a therapist.

1 Introduction

The use of robotics in healthcare has been widespread for several decades. It is common to find this technology in operating theatres, pharmacies, or rehabilitation and therapeutic intervention centers. In the latter, it is frequently used to approach and treat bodily functions such as gait disorders. These types of robots belong to a certain area of robotics known as assistive robotics.

Personal mobility and the ability to move around is one of the most important activities in our daily lives and one of the basic aspects of achieving greater independence. Different neurological or musculoskeletal diseases can cause gait alterations. To treat them, it is necessary to follow a rehabilitation process, guided by the corresponding professionals. These specialists configure and generate work environments that involve using and applying various techniques, physical resources, and materials to address the needs and improve the skills of the person in question. As indicated above, within these environments the inclusion of assistive robotics is frequent, although other technologies such as virtual reality are also used. (Miranda-Duro, et al., 2020).

Thus, the aim of this work has been the programming of a low-cost mobile robot that acts as an assistant in gait rehabilitation sessions, guiding, accompanying, and motivating the person and helping to reduce the workload of the health professional. In this way, it is proposed that, after this internal configuration, the robot would execute a route previously designed by the therapist, so that the user would follow it until completing the route. In addition, its speed would be adjusted according to the gait of the person it is assisting.

The work was carried out with the support of physiotherapists and occupational therapists from ASPACE Coruña, a non-profit organization that provides comprehensive care for people with disability.

2 Materials and Methods

For the development of the project, different technologies and tools have been analyzed and used. The main device is a TurtleBot3 (TurtleBot3) (Figure 1), a low-cost, programmable, ROS-based mobile robot. Its applicability focuses on the use of SLAM, navigation, and manipulation. In terms of software development, ROS (ROS), a free and open-source *framework* and *middleware* to develop and execute robot applications according to a series of computational and communication models, is used. Another technology of note is SLAM, a navigation technique that allows a mobile robot to build a map of the environment while navigating through it. This is the result of the implementation of algorithms in combination with the information captured in real-time by the robot's (Martínez, 2020).

Figure 1: TurtleBot3 Robot

Before programming the TurtleBot3, a meeting was held with the physiotherapists of ASPACE, to obtain the opinion of professionals and the perspective of the users on the mobility needs to be covered with the use of the robot. This has made it possible to define the functionalities necessary to achieve the project's objective, which are fundamentally the following:

- ### Route execution

First, it has been necessary to create a map of the environment. To do this, the *SLAM* and *Teleoperation* packages have been used, both provided by the manufacturer of the TurtleBot3, which, in turn, make use of other packages available in the ROS community. For the action of navigating the environment, this map, and the *Navigation* package, also provided by the manufacturer, are used. This package allows a map to be loaded and targets to be sent to the robot. These targets are coordinates to which the robot will move. Taking this into account, a set of points has been selected on the map, the achievement of which by the robot represents the route to be taken. To control the sending of targets to the robot, the *actionlib* package is used, which implements a client-server communication. Using the previous packages, an own package has been developed that is responsible for sending different objectives to the TurtleBot3, and for controlling the achievement of these objectives, so that it carries out the route that will form part of the rehabilitation work.

• Speed control

Another requirement that the robot had to meet was that it should be able to adapt its speed to the gait of the person, thus avoiding possible falls or loss of tracking. To this end, an ideal distance between the user and the robot has been established and LIDAR has been used as a detection and measurement element. To adjust the detection range to the user's legs, it has been necessary to develop a package to filter the received signal. On the other hand, a second package has been developed in which a proportional system has been implemented which, based on the previous data, allows the speed of the robot to be adjusted according to the distance at which the person is located.

3 Results

After implementing the necessary functionalities, the TurtleBot3 can assist a person during the gait rehabilitation process. The robot has a map of the working environment at ASPACE and a set of coordinates according to the route design provided by the occupational therapists. Once the activity starts, the robot goes to each of the coordinates while measuring the distance to the user through the LIDAR. In this way, it performs the designed route, varying the speed according to the pace of the person.

4 Conclusions

The objectives of the project have been met, programming an assistive robot capable of guiding ASPACE users in their intervention process on autonomous walking skills. It is worth mentioning that the low cost of the robot has not been a limitation in terms of the implementation of the necessary functionalities to carry out the project. In addition, the use of ROS has made it possible to implement the necessary functionalities with minimal development in terms of programming, as a result of the reuse of packages available in the community.

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