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Towards a new generation of TIAGo robots

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***Abstract*—The TIAGo robot is among the most popular mobile manipulators in the European research ecosystem. It features hardware that allows it to perceive and connect with its environment, manipulate objects, autonomously navigate and interact with people. The new trends in robotics and the so-called industry 5.0 make a strong emphasis on the latter, both from a physical and a conversational perspective. In this extended abstract we briefly present the new version of the TIAGo robot, TIAGo Pro, by highlighting the most relevant hardware upgrades. Here the ongoing European Collaborative projects where this new platform will be used are also outlined.**

***Index Terms*—Autonomous Mobile Robot, mobile manipulation, HRI, torque control**

I. Introduction

The original features of the TIAGo robot (second leftmost robot in Figure 1), as when it was created in 2014, are a differential drive base with circular top view with a 2D LIDAR in front of it, a lifting prismatic torso, a 2 Degrees of Freedom (DoF) -pan and tilt- head with an RGB-D camera and a frontally mounted 7 DoF arm with a parallel gripper. This is all integrated in a single robot that is fully based in the popular Robot Operating System (ROS). This endows the platform with the ability to navigate autonomously, perceive its surroundings and manipulate the environment. All its capabilities can be directly combined to perform tasks of the sort of the so-called Industry 4.0. See [1] and references therein.

Fig. 1. Different configurations of the TIAGo robot. Left to right: TIAGo Lite, TIAGo, TIAGo++, TIAGo OMNI and TIAGo++ OMNI

There has been a continuous update of the robot, both from the software perspective and also from the hardware point of view [2]. The hardware upgrades of the robot have been always done by boosting the modularity of the platform, that currently can be obtained with 2 different types of base -differential drive and omnidirectional drive- and with either no arms, with a single arm and in a dual arm configuration. Figure 1 shows 5 possible configurations of the TIAGo robot.

The main focus of the so-called Industry 5.0 is human-centricity and collaboration. While TIAGo is able to fit within this scope, the prospective systematic deployment of such platforms has some certification requirements that can only be attained via a major hardware upgrade. Recently, through the H2020 CANOPIES[1] project, PAL has developed a new arm technology for the TIAGo robot that fosters safe human-robot collaboration and interaction that is compatible with certification at the European level. This new arm technology has been combined with efforts to boost the interaction capabilities of the robot to create a new version of the TIAGo robot, the so-called TIAGo Pro. This short note introduces this new robot.

In Sec. II the TIAGo Pro robot is described, with special emphasis on the arm and head technology. Sec. III is devoted to briefly outline the forthcoming applications of the robot through the case-studies of publicly funded European collaborative projects. A prospective view of the future of the platform is outlined in Sec. IV.

II. The TIAGo Pro robot

The TIAGo Pro robot is shown in Figure II. This platform is a bi-manual mobile manipulator mounted on an omni-directional base. It also features a head with 2 DoF. While similar to the TIAGo++ OMNI robot, see the rightmost robot in Figure 1, this robot features a number of upgrades that makes it suitable both for research in a wide range of fields in robotics and also in applications that range from healthcare and elderly care all the way to the manufacturing industry. This has been fully designed and built by PAL Robotics.

A. New robotic arms

The arms feature an iteration of the new actuation technology developed in the context of CANOPIES, see Figure II-A. These actuators have a Series Elastic Element embedded in them (hence they are Series Elastic Actuators or SEA). This reduces the torque sensing to manipulating the readings of the input and output encoders the actuators have.

To be able to use the torque readings for joint torque control with enough bandwidth, the communication bus used here is EtherCAT at at least 1KHz. Adapting all the components to

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[1]`https://www.canopies-project.eu/`

Fig. 2. The TIAGo Pro robot

Fig. 3. New TIAGo arms with Series Elastic Actuators

the slim design of the arms required an ad-hoc design both for the actuators and for the electronics, that has also been fully designed by PAL. The actuators also have brakes, that provide an extra layer of safety when it comes to human-robot collaboration.

B. New arms mounting

The requirements of mobile manipulators such as the TIAGo robot in all application fields include manipulability constraints. Namely, the robot should be able to reach the floor, a table top and a shelf comfortably. The design of the arm and its mounting has been done to satisfy this constraint. The mounting of the arms has been determined by means of an optimization procedure that not constrains the robot to be able to reach these three heights, and maximizes the common workspace between the arms to take the most out of the bi-manual configuration of the robot.

C. New head

The new head of the TIAGo Pro robot has been designed with emphasis on the non-verbal communication in the human-robot interaction. The head still features an RGB-D camera, yet here both speakers and microphone have been mounted on the head to boost interactions. The screen in the face and the LEDs also allow the robot to express a wide range of emotions.

III. Fields of application

All the robot redesigns have been done and justified in the context of the applications and case-studies of publicly funded EU collaborative projects.

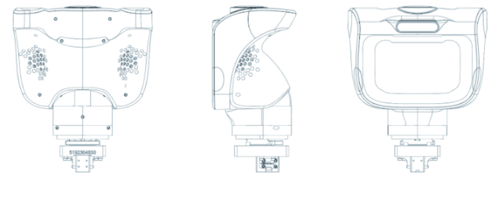

Fig. 4. Detail of the new TIAGo Pro head

1) **CANOPIES - AgriFood**. The goal of this project is to develop a Human-Robot prototype in crop farming (Agri-Food) that addresses the challenges of Human-Robot Interaction and Human-Robot Collaboration. The main outcome of this is the first iteration of the new actuation system for the robot arms.
2) **AGIMUS[2] - Agile Manufacturing.** This project aims to deliver an open-source breakthrough innovation in AI-powered agile production, introducing solutions that push the limits of perception, planning, and control in robotics, enabling general-purpose robots to be quick to set-up, autonomous and to easily adapt to changes in the manufacturing process. Here the main outcome is to deploy and use the robot in relevant scenarios that showcase collaboration with humans in real manufacturing environments.
3) **Pillar Robots[3] - Autonomy Research**. This project aims at developing a new generation of robots endowed with a higher level of autonomy, that are able to determine their own goals and establish their own strategies. The project will operationalize the concept of Purpose, to increase the autonomy and domain independence of robots during autonomous learning and, lead them to acquire knowledge and skills relevant for operating in real applications.

IV. Future work

The future actions revolve around the deployment of the platforms in the contexts set by the projects listed in Sec. III and the certification of the platform.

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[2] https://www.agimus-project.eu/

[3] https://pillar-robots.eu/