@WORK - TEAM DESCRIPTION PAPER(TDP)

1st Danilo Hernani Perico
Centro Universitário FEI
Av. Humberto de Alencar Castelo Branco, 3972
São Bernardo do Campo, São Paulo, Brasil
Email: dperico@fei.edu.br

2st Caio Puertas Popolin Garcia
Centro Universitário FEI
Av. Humberto de Alencar Castelo Branco, 3972
São Bernardo do Campo, São Paulo, Brasil

3st Nicolas Kuhnast
Centro Universitário FEI
Av. Humberto de Alencar Castelo Branco, 3972
São Bernardo do Campo, São Paulo, Brasil

4st Thainá Almeida Santos
Centro Universitário FEI
Av. Humberto de Alencar Castelo Branco, 3972
São Bernardo do Campo, São Paulo, Brasil

5st Thiago Ornelas Aravena
Centro Universitário FEI
Av. Humberto de Alencar Castelo Branco, 3972
São Bernardo do Campo, São Paulo, Brasil

6st Victor Magalhães Oliveira de Mello Ayres
Centro Universitário FEI
Av. Humberto de Alencar Castelo Branco, 3972
São Bernardo do Campo, São Paulo, Brasil

***Abstract*—This article introduces the RoboFEI@Work team and explains more about the current project and its further improvements. The project has begone in 2022, developing a robot based on KukaYoubot for industrial purposes. But in 2023 with a new team resuming the project. Our participation in the competition will be to put our robot to the test and improve imposed systems.**

I. Introduction

The use of robots, in the domestic environment as well as in the industrial, has been growing exponentially over the last decade. Creating a new search field and an ever-growing market. Gradually robots are taking over homes and offices and already have taken most of the industry. [1]

This research group aims to bring more visibility both in the research environment and in the competitive environment of industrial and agricultural robots. The idea is to work primarily on industrial problems, but our team has similar tasks to those proposed by robocup@Home. Enabling an iteration with our team in this competition.

The RoboFEI@WORK was created in the second half of 2022 at FEI University as a research team for industrial and agricultural robots. To solve the proposed tasks, was developed a robot using Kuka Youbot as a base. its internal system was entirely changed, such as the hardware and software, with further explanation in the following topics.

The objective of this document is to present this new team and its main characteristics, demonstrating this robot's capabilities and the main work done.

The video of the robot can be found here: https://youtu.be/5ui18oPHxUk. The website of the team is https://fei.edu.br/robofei/.

II. Focus and interests

The focus of this project is to develop a robot to participate in national competitions and RoboCUP@Work competition. The robot will act in fields that simulate an industry, making tasks about navigation, vision and object manipulation. About the interests we want to promove this competition in Brazil helping to create a new category for @Work robots to compete in high level. Moreover due to the fact that RoboCUP@Work have their similarities with RoboCUP@Home we can participate of RoboCUP@Home until it is possible to compete with other teams in @Work category.

III. Electronics

This section explains the new electronics of the robot, using new microcontrollers for each motor and a new PCB (Printed Circuit Board), which was created using Kicad 6.0. [2]

A. ESP32

To control the motors was used an ESP32 devkit as a PWM sender to the microcontrollers. The ESP32 was programmed using Arduino IDE and C++ so that messages could be sent using serial communication via Bluetooth or cable. In order for, it can receive the message and transform it into a PWM pulse. The logic for the pulse is simple, it is used half of the length as a starter point, if created a pulse with 10 bits it should be able to go from 0 to 1024, so 512 the motors should be stopped. At 0 the wheel would go in a direction, let's suppose right, and in 1024 it should go left. The numbers in between serve to control the velocity, at the moment we set the pulse depending on the rpm of the wheel.

B. Microcontrolers

We used the STM32G431CB microcontroller to act as an H Bridge, so in that way, could be used a PWM pulse for controlling, both the direction of the wheels as well the speed. A pulse of 10 bits is being used to have a better performance. However, the microcontroller only reads pulses close to 5V, and the ESP32 only sends signals in 3.3V. Because of that, was needed to make an amplifier using MOSFETs.

C. Main board

The main board was created to substitute all the cables and use minimum space as possible making everything organized. It contains the connection between ESP32 and microcontrollers, ESP32, encoder, and the step down to decrease the voltage from 12V to 5V, which is what the microcontrollers can receive.

IV. Software

This section will be presented the means of vision and navigation of the robot.

A. Robot vision

The vision system allows the robot to identify and recognize objects and humans. Using the Microsoft Kinect sensor and ROS [3], it can process images taken from the real world. Thus it is possible for the robot locates any type of object, given the need for the task. In Robocup@Work, the robot needs to locate utensils positioned in strategic places, being an important tool for the robot, so it is possible for it to locate and search given a certain task.

The group uses MobileNet [4] and Yolo [5] tools to develop computer vision. MobileNet is a class of convolution and a simplification of neural networks designed to facilitate image processing. It works by dividing the image into pieces and passing each piece to a neural network, from a database the algorithm will produce a percentage of what the photo looks like [6]. YOLO is a single-pass object detection method that uses a convolutional neural network as a feature extractor. This tool only needs to look at the image once to send it to the neural network, being faster for certain actions. [7]

From these tools, the robot can identify certain people and objects, enabling its interaction with the environment around it. Thus, given a certain task, the robot can perform better using its vision.

B. Robot Navigation

Navigation makes it easier for the robot to move through known and unknown spaces, Given a certain environment the robot can move between points. During the RoboCup@Work competition, the map is generated by the robot. Therefore, given a certain task, our robot can be driven to operate it.

When the robot is in an unknown location, it must know the environment its surroundings, mapping and at the same time defining its position in space. This technique is known as Simultaneous Localization and Mapping (SLAM). In navigation, the robot has the capacity to choose the best possible route and avoid possible obstacles. For this to happen, it determines parameters where there is the slightest path error and the robot is constantly correcting it.

SLAM is a technique used in several mobility areas to build maps of environments at the same time as their location. Through sensors, SLAM can estimate the position and orientation in spaces. [8]

C. Robot manipulator control

At the moment we have a code that is capable to control all six motors from the manipulator. It is done based on the motors' positions.

V. Mechanics

The mechanics focus to change the structure using new materials which are lighter than the previous one and improving the manipulator.

A. Structure

Was created a new structure that covers almost everything inside the robot using MDF, which is a light material, helping us to decrease the weight so the motor will not need a higher use of current to function well. Therefore, increasing the autonomy of the robot.

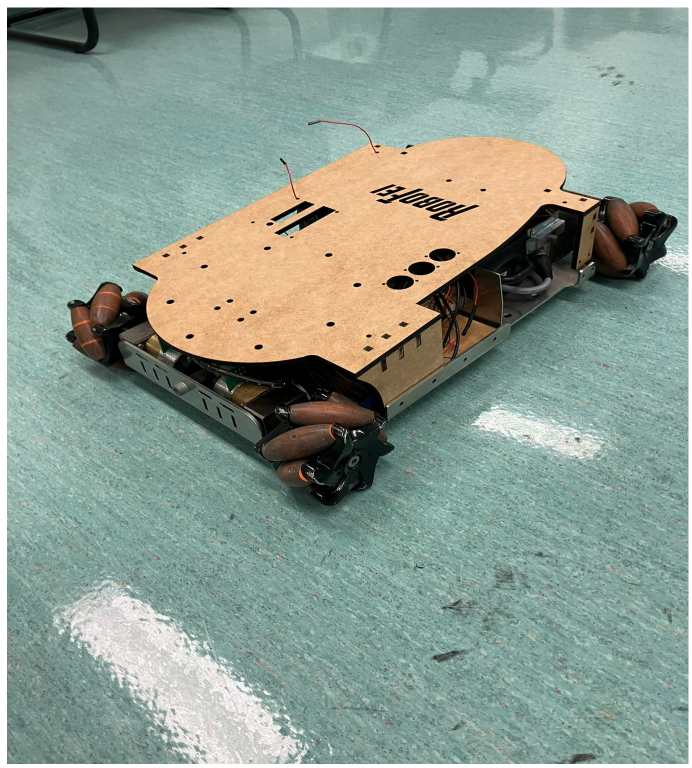

Fig. 1. developed structure

B. Manipulator

The previous group developed a manipulator capable of solving the tasks but some problems were found related to the claw and the base. Because of that, we are working on developing a new claw that is capable of grabbing all the objects, and a new base to support the manipulator properly. In addition, the manipulator uses 6 MX-64R Dinamixel motors, and this year two of them will be changed for new ones, called XM540-W270R.

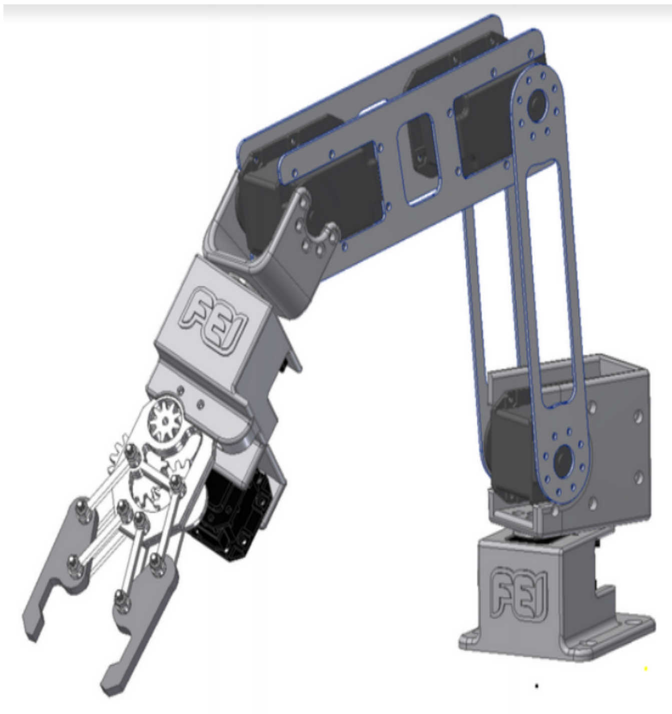

Fig. 2. developed manipulator

VI. Conclusion

Thus, this work presented the team development towards 2024. Our goal will be always to get knowledge by participating in competitions to improve the software system and hardware increasingly.

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Robot Technical Specifications

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Hardware Description:

- Base: Mecanum Wheel Robot platform.
  - Sensors:
    - Lidar.
  - Actuators:
    - Omnidirectional wheels.
    - Maxon motor.
- Manipulator.
  - Actuators:
    - Dynamixel motors;

Software Description:

- Arduino IDE
- Visual Studio Code

Fig. 3. our robot in its first version

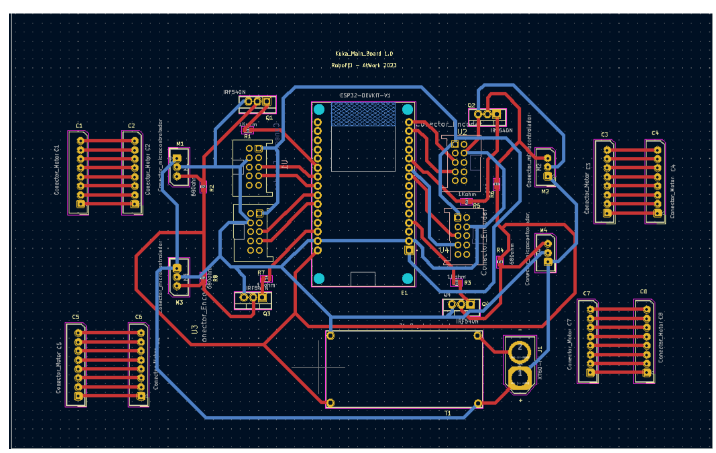

Fig. 4. main board