ABOUT MYSELF

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Presentation and Motivation

I am Enrico Moro, a Bachelor's student in Mechatronics Engineering at the University of Padua. I am very interested in your proposals, and I believe the "Payload Visualization and Metrics" project is the most relevant to my background. I have studied forward kinematics and I am currently taking a course on multibody simulation in MATLAB. This project could significantly enhance my knowledge and experience in robot simulation, an area that is becoming increasingly crucial for future engineering challenges.

Previously, I developed a robot with a similar structure to your Tiago, where determining the maximum payload was a critical aspect. Throughout my engineering studies, I have learned the importance of optimization in motor selection and material usage to reduce costs and extend the machine's lifespan. This project would be a valuable opportunity to apply and deepen my understanding of these concepts, contributing to better hardware choices and efficient system design.

Expectation from the project

I see GSoC as a good opportunity to learn a deeper understanding of the open source world. Furthermore this is a chance to demonstrate my skills and learn a lot more. Another thing that is very important for me is meeting new people from around the world, sharing different ideas that could potentially bring a better final project and new friendships among contributors.
Regarding the PAL project, for me it is a great opportunity to apply the knowledge acquired during my studies in Mechatronics Engineering and to strengthen my understanding. I have studied rigid body motion and inverse dynamics for articulated mechanisms, using both analytical solutions and recursive methods. I would know more about the possible implementation in a real robot and this project is a perfect fit for my goal.

Analysis of the project: Payload visualization metrics

The project consists of a tool to provide the maximum payload that the robot can handle in a specific configuration and so the required torques of the motors.

Steps to achieve the final goal:

- **Rviz visualization plugin:**
    - A simple GUI interface inside Rviz is always a good idea for user-friendly output and a easy access to obtain the expected results.
    - I have already created a simple plugin that displays the current joints, frame transform of a selected frame(chosen with a drop-down menu) and collision between bodies, all the configuration is retrieved by the robot description topic.
    - During the project, we need to add the visualization of the maximum payload and all the required torques of the motors.

- **Module for torque requirement and maximum payload computation:**
    - First, it is necessary to obtain the current robot description with all constraints and inertia measurements.
    - Next, we retrieve the desired configuration from a specific topic (e.g joint state data provided by Tiago description launch file with robot state publisher)
    - We compute inverse dynamics with some library **(**e.g. Pinocchio). For the computation of the maximum payload we need to know the maximum allowed torque of the current motors and verify with inverse dynamics when a possible payload exceeds the limits of the maximum torques.
    - To configure this module, we could connect this script with the Rviz panel in order to choose the specific action that the “payload_estimation.cpp” script will execute.
    - The computed data will then be published to a topic where the Rviz subscribes and gets the data to display.
    - If the user wants to get the torques necessary for a given payload the script will compute inverse dynamics and publish the estimated torques for that payload.

- **Two functional modes:**
    - 1) Compute the maximum payload for a given configuration and known motor limits (torques).
    - 2) compute the motor torques for a given configuration, inertia data and payload.

- **Other ideas to implement:**
    - From a catalog of motors, we could create a simple module to suggest a possible motor for the current application and torque requirements.
- **Things to clarify:**
    - For dynamics calculations, we require joint velocities and accelerations. What are the available inputs for these data?

Project timeline

My goal this summer is to work in an environment that will significantly improve my skills, and GSoC presents a fantastic opportunity. I will complete my Bachelor's degree in June, so during the first part of the month, I may have limited availability. However, after that, I plan to dedicate myself to GSoC as a full-time commitment for the summer. Since I will start my Master's degree in October, I will have ample time to focus on coding.

Possible key element for the project:

- Get the `robot_description` with all actuation constraints and display them in a custom RViz panel.
- Develop a ros package containing a script to compute the available payload for a given configuration and publish the results to a specific topic for visualization in the RViz custom panel.
- Implement another script to manage torque, power, and stiffness calculations for the motors. A possible initial approach is to use the rnea() method from the Pinocchio library. Then the results will be published to a topic and displayed in the RViz panel.

Technical information

I have been using ROS2 for two years especially in my main project, SBEM. You can find SBEM in my GitHub repository: Sbem. I regularly work with Ubuntu 22.04, leveraging it for both personal and school-related projects.

Recently, I have been exploring AI agents and integrating them into SBEM to enhance human-robot interaction. I have achieved some promising results in this area. Additionally, my GitHub repository includes a GUI interface built with Electron.js, which enables users to chat with an AI model and interact with the robot seamlessly.

Beyond the three exercises I provided for selection, I also created a simple plugin in RViz2 (GitHub repository: repo) to integrate the Pinocchio library. This could serve as a starting point for the future development of the project.

Additional skills:

I am proficient in CAD software for designing 3D-printed objects and have considerable experience in 3D printing. Additionally, I have a strong background in electronics and mechanics, which I studied extensively during my bachelor's degree in Mechatronics.

Other achievements:

In my final year of high school, I participated in a national robotics challenge, where my team won first prize. As a result, we had the opportunity to present our prototype at Maker Faire 2022 in Rome. Our project was an exoskeleton built using a Teensy board and two AK motors from Cubemars Robotics.

I thought about participating in GSoC 2024, but last year I didn’t feel ready for the opportunity.