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MPSYS TECHNICAL MINI FAIR

Master programme: System, Control and Mechatronics

Collaborative-Robot Assistant for Technicians

Introduction

The next generation of Collaborative Robots (Cobots) will help humans with repetitive and high-loaded tasks. This project worked with TIAGo in ROS to develop compliant controllers, and further developed a digital twin made by a bachelor thesis in Unity.

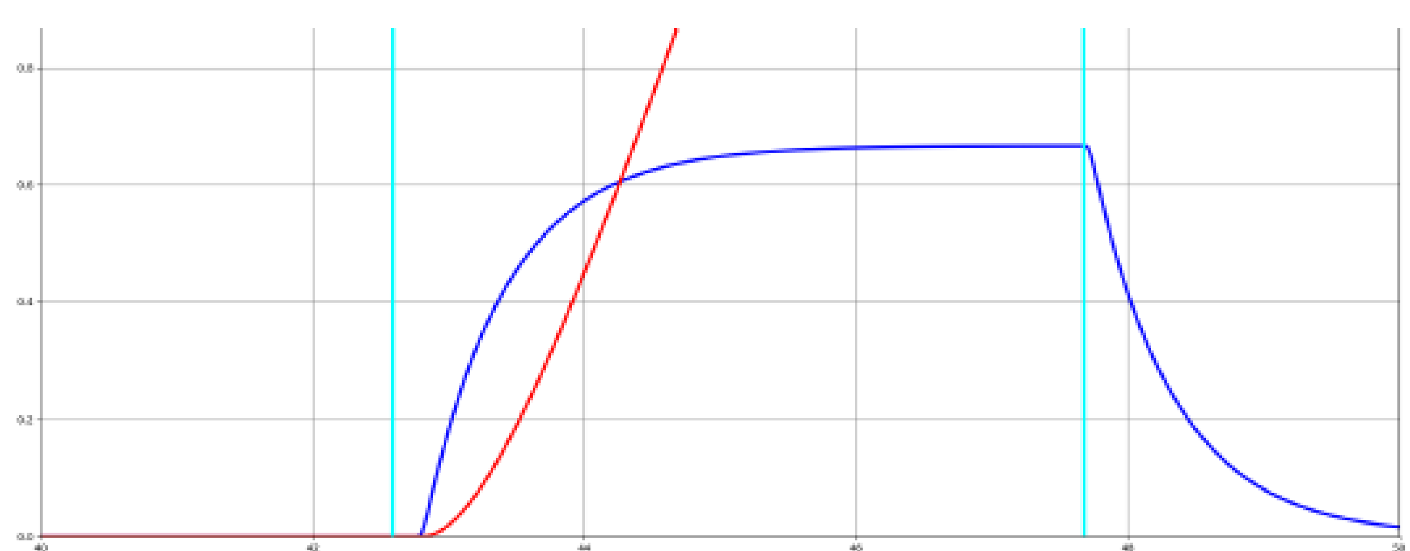
Project scope:

1. Design controllers allowing operators to collaborate with TIAGo.
   - ROS1, ROSControl, C++
2. Further develop digital twin of TIAGo for training and learning purposes
   - Improve odometry

Methods and Results

Base controller:

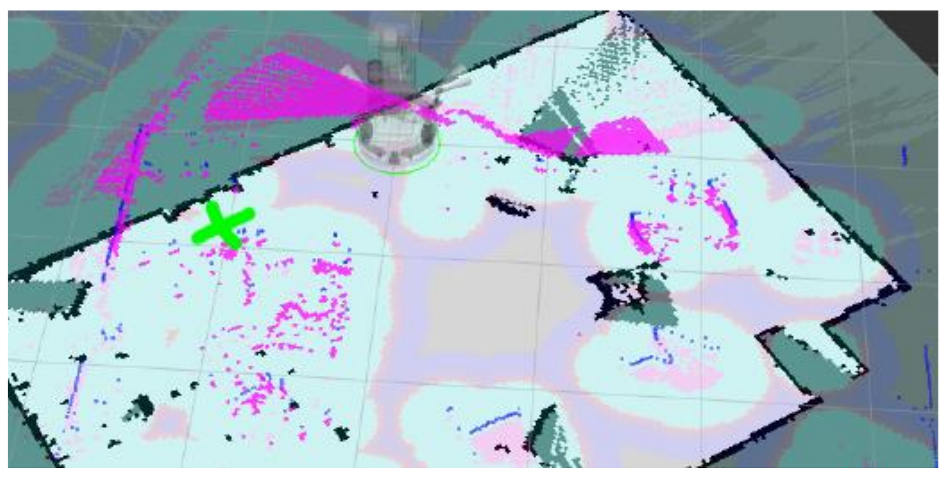
- Differential drive
  - Translate linearly forward and backwards
  - Rotate around the vertical axis
- Algorithm
  - Read force input from force-torque sensor
  - Derive desired velocity based on applied force and current velocity
  - Send desired velocity to /cmd_vel



Velocity and position plotted as a result from the base controller, a reference force of 50 N is applied and corresponds to the light blue line. The red line is the position and the dark blue is the velocity.

Digital twin:

- ROSBridge Unity client
- ROS topics accessed from VR
- Improve odometry by subscribing to pose msg
- Gmapping and Localization



Arm controller:

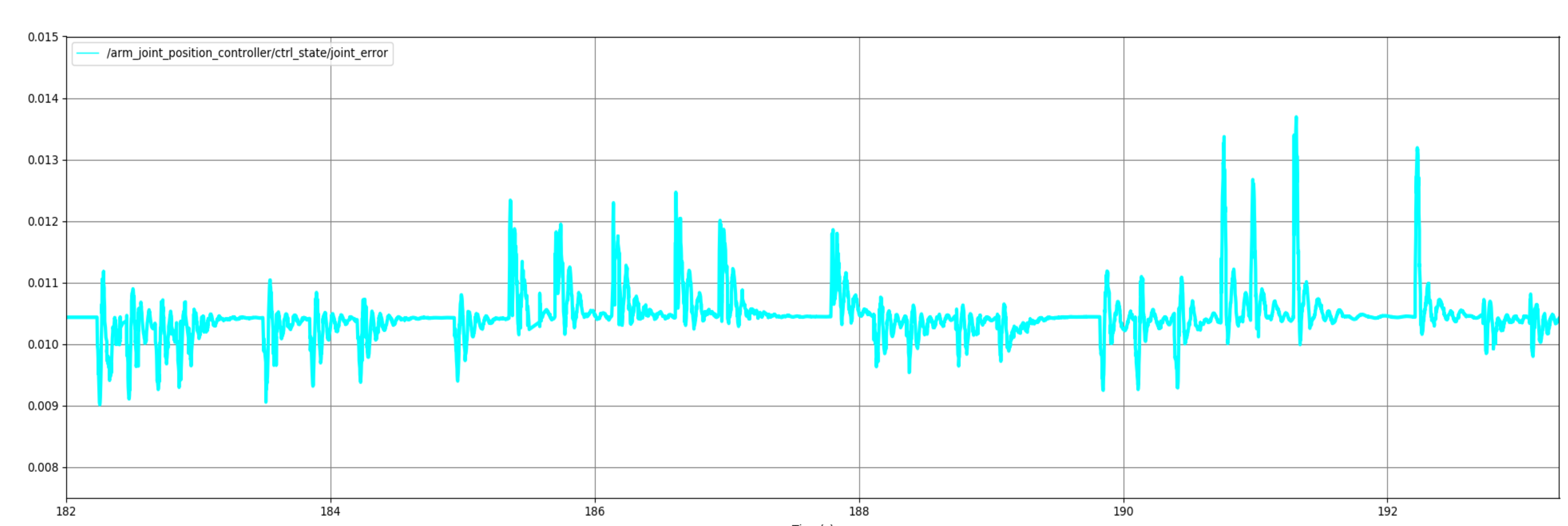
- Kinematic open loop controller, 7 dof
- ROS Control
- Task space and joint space
  - Solve for change in joint position

$$\dot{x} = J(q)\dot{q} \Rightarrow \Delta x \approx J(q)\Delta q$$

- Algorithm

Algorithm 1 Kinematic control algorithm

Ensure: $\Delta x = 0$
while controller is running **do**
  $J, R_e^b \leftarrow jacobian\_and\_end\_effector\_frame()$
  if $F > F_t$ **then**
    $\Delta x(1:3) \leftarrow R_e^b normalize(F)$
  else
    $\Delta x(1:3) \leftarrow \alpha \Delta x$
  end if
  if end-effector orientation is constant **then**
    $J^\dagger = J^T(JJ^T)^{-1}$
    $\Delta q_d = J^\dagger K \Delta x$
  else
    $J_p^\dagger = J_p^T(J_p J_p^T)^{-1}$
    $\Delta q_d = J_p^\dagger K(1:3, 1:3)\Delta x$
  end if
  $q_d \leftarrow q_d + \Delta q_d$
end while



Norm of the error in joint positions vs time. Every large spike corresponds to a new force reading. Note that there is a steady state error.

Discussion

- Slipping wheels
- Gmapping and Localization
  - Large errors, no odometry improvements
  - Configuration errors?
- Further work
  - Enable interaction from the digital twin
  - Hierarchical control

Conclusion

- Compliant controllers produced smooth movement in simulation
- Odometry in the digital twin
  - Perfect estimation from simulation
  - Inaccuracies from real world

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