

F&P Report:

Collaborative robot P-Rob® - a great platform for research and education

The personal robot P-Rob 2 of F&P Robotics is an ideal platform for researchers in the areas of robot control, human-robot interaction and artificial intelligence. It covers most needs for advanced developments:

- Embedded PC running on Linux (Ubuntu)
- High performance ROS support
- Python Scripting Language with full power just through a web browser interface (no additional installations needed)
- 6 DOF robot arm, intrinsically safe (24 V version)
- Angular two-finger Gripper with integrated sensorics (adaptable). Active infrared on fingers, position, velocity and force control and distance sensor in middle of gripper
- Adapter for third-party grippers
- Camera module on gripper or standalone
- myP software for comfortable control of Robot and extensions based on web browser based GUI
- real-time motion control module to be used independent written in C++ allowing to connect to any robot control software including MoveIt (ROS)
- Position, velocity and torque (based on power consumption) control for each joint
- Optionally separate high-resolution 6 DOF force-torque sensor, positioned between arm and gripper
- Integrated features to
 - o Support for IP-Sockets to integrate separate layouts, sensors, cameras etc.
 - o Apply neural learning machine for object recognition
 - o Situation planner based on probabilistic reasoning
 - o Support of face, gesture and language recognition
 - o Build own skills as combination of functional scripts and hardware components
 - o Connect to linear axes and mobile platforms
- Options for linear axes and AGVs hardware, already connected to software environment and Slam architecture
- 3D grid teach-in wizard
- Simulation possibilities with Gazebo (ROS) and separate myP functions (showing moving arm and all teached points in space).
- Modbus TCP Ethernet interface to connect to any PLC (Siemens, Mitsubishi, Beckhoff, Wago etc).
- Digital I/Os and CanOpen connection possibilities at robot socket.

Let's highlight some of these aspects.

1. Motion Control Module (MCM)

The Motion Control Module provides a very fast (control loop up to 100 Hz) control interface of P-Rob2. It aims at an easy integration into different existing software frameworks using JSON over TCP/IP as a means of communication. It is intended to be used for Machine-to-Machine (M2M) communication and provides also an optional text-based Human-to-Machine interface (HMI).

Features

- Calibration (using mechanical stops or light barriers, if available)
- Position control loop up to 100Hz providing smooth movement
- Release mode allowing positioning the robot by hand with friction and gravity compensation
- Sophisticated safety checks in all modes
- Well tested (coverage estimated at 95% of the code base)
- TCP JSON-based M2M interface

Options

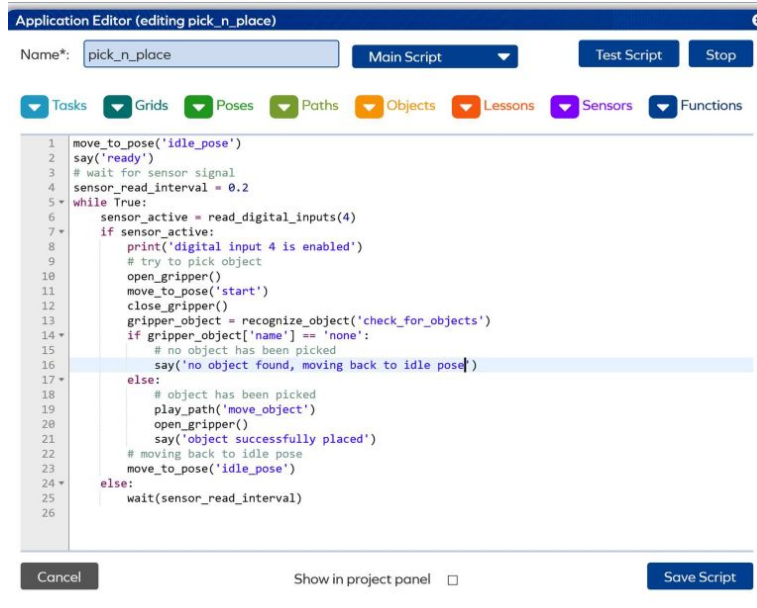
- TCP text-based HMI interface
- C++ API
- Python API
- ZMQ interface

Operating modes

- HOLD: Axes are kept at their current positions
- RELEASE: Axes can be moved by hand
- Smooth position control through PVT (Position-Velocity-Time mode)
- TORQUE_CONTROL: Torques provided by external controller
- VELOCITY_CONTROL: For reactive trajectory modification and online motion planning
- OFF/ERROR: Axes are kept at their current positions. Axes powered OFF or in error state

2. myP Software

Powerful software package for robot control, teach-in, scripting, automatic task generation, learning modules based on neural networks and probabilistic estimation. Easy teach-in functions with hand guidance of the robot to sophisticated programming using python libraries and dozens of myP functions for P-Rob. Dynamic robot model allowing gravity compensation, movement optimization and interaction with environment, humans and other robots.



The screenshot shows the 'Application Editor' window for a script named 'pick_n_place'. The interface includes a toolbar with buttons for 'Main Script', 'Test Script', and 'Stop'. Below the toolbar are several tabs: Tasks, Grids, Poses, Paths, Objects, Lessons, Sensors, and Functions. The main area contains a Python script with the following code:

```

1 move_to_pose('idle_pose')
2 say('ready')
3 # wait for sensor signal
4 sensor_read_interval = 0.2
5 while True:
6     sensor_active = read_digital_inputs(4)
7     if sensor_active:
8         print('digital input 4 is enabled')
9         # try to pick object
10        open_gripper()
11        move_to_pose('start')
12        close_gripper()
13        gripper_object = recognize_object('check_for_objects')
14        if gripper_object['name'] == 'none':
15            # no object has been picked
16            say('no object found, moving back to idle pose')
17        else:
18            # object has been picked
19            play_path('move_object')
20            open_gripper()
21            say('object successfully placed')
22            # moving back to idle pose
23            move_to_pose('idle_pose')
24        else:
25            wait(sensor_read_interval)
26

```

At the bottom of the editor, there are buttons for 'Cancel', 'Show in project panel' (with a checkbox), and 'Save Script'.

Script Editor of myP, available directly inside the browser application

3. ROS Integration

P-Rob supports a direct ROS connection to the backend allowing users to send commands and receive information with high performance. This ROS package “myp_ros” contains everything you need to integrate P-Rob into your ROS environment.

Check it out at https://github.com/fp-robotics/myp_ros

Additionally, a **gazebo model of P-Rob** is available, allowing standalone and synchronized simulation of the collaborative robot. The following zip folders are provided:

fp_gazebo:

This contains the gazebo model, a joint angle plugin which connects with ROS, and a world file which loads the model and plugin. In here are two scripts, setup.sh to build everything, and run.sh to run the world in gazebo (a roscore is required).

fp_descriptions:

This contains the URDF models for use in RViz.

4. Product Overview



Additionally, many extensions are available including:

- Linear axes
- Mobile platforms
- Support of collaborative third-party grippers such as SCHUNK Co-act-EGP



Personal Service Assistant Lio, including P-Rob and a sophisticated sensor equipped mobile platform

Benefits Summary

- ✓ P-Rob is well suited for collaborative robotics as well as service robotics. During the design and development of P-Rob, great attention was paid to situation awareness

and adaptive behavior as well as the intrinsic safety concept. The software myP offers a very easy way of teaching and communicating with the robot including vocal and body language. The soft shell of P-Rob with a synthetic leather skin lowers haptic barriers and offers unique opportunities for sensor deployment.

- ✓ P-Rob is more than just a robot arm. The all-in-one concept (robot arm with embedded PC plus gripper plus software) allows fast and simple automation of both stationary and mobile work stages. Compared to ordinary industrial collaborative robot arms, no external devices, like controller boxes or third-party PCs, are needed.
- ✓ P-Rob focuses not only on its tasks but also on its working environment. Using algorithms of artificial intelligence, optional sensors and vision systems, the environment can be perceived and specific actions can be carried out depending on the actual situation. Furthermore, P-Rob can control all kind of devices via numerous interfaces, allowing mobile platforms, machines, linear axis and many more to be easily integrated into automation solutions.
- ✓ The combination of embedded PC with local computer devices and online cloud functions allow infinite possibilities for research and advanced mobile service applications.

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