An Industrial Dual Arm robot and application

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Smart Dual Arm features

Taking advantage from its configuration Smart Dual Arm permits to manage a wide range of applications, guaranteeing the following features:

- **Human** like approach
- **Intuitive and effective HRI** (human robot interaction)
- **Motion Dexterity**
- **Flexibility**
- **Integrated solution**

Smart Dual Arm overview

The Smart Dual Arm is an innovative robot with the following characteristics:

- **2 anthropomorphous Arms** with 6 axes
- **1 positioner arm for the TORSO** (1 axis)
- **10 kg payload** per arm (tot: 20kg)

- A total of **13 axes** managed by the **same C5G** controller unit

- **Cooperative motion** (spatial synchronization) among the two Arms and Torso
- **Syncmove** (timing synchronization) among the two Arms and Torso

- **Hollow wrist arms** for optimized outfitting.

Smart Dual arm applications

Several applications are been executed or under testing so far; most on the assembling, disassembling and handling fields. Some example:

- Hydraulic pump **assembling**
- Gear box **assembling**
- Sewing machine **disassembling**
- Mechanical parts **handling**

Laboratory of technologies

Beside of its industrial purpose the Smart Dual Arm solution has been thinked as a multipurpose laboratory where new technologies are tested and integrated. Currently a lot of new devices and solution are under development:

- **Gripper** devices for assembling
- Devices for **fenceless approach** (safety eyes by PILZ, stereocameras)
- Automatic **Screwing device**
- **Vision system** for parts recognition
- **Force torque sensor**
- Devices for **easy programming** (gesture and vocals recognition)
- Integration of **C5G open control** and **ORL** libraries

OPEN CONTROLLER Concept

Open approach adds to Robot Control Unit further power of an External Personal Computer for programming *automated robotic cells* and integration with ***external sensors*** to simplify the implementation of *complex manufacturing applications*

Vision Algorithm:
- Look & Move
- Visual servoing

Interaction Algorithm:
-Force control
-Impedance control

CAD Planning:
-Surface movements
-Complex Interferences

For *universities* and *research centers*

Open architecture permits to develop new innovative motion strategies.

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C5G Open Improvement

C5G Open is suitable for some industrial application that need additional sensors integrated in the system. For this purpose used hardware parts have to be compliant with the industrials regulations and software architectures has to be more easy to use.

Hardware: B&R LPC (Linux APC) permits to run C5G Open on a industrial hardware platform

Software: Ubuntu distribution patched by B&R is fully compliant with B&R PowerLink Interface Card with a communication rate @ 400us

eORL: C5G Open works in Cartesian frame also and can manage multi ARM configuration, details of communication are hidden to the user

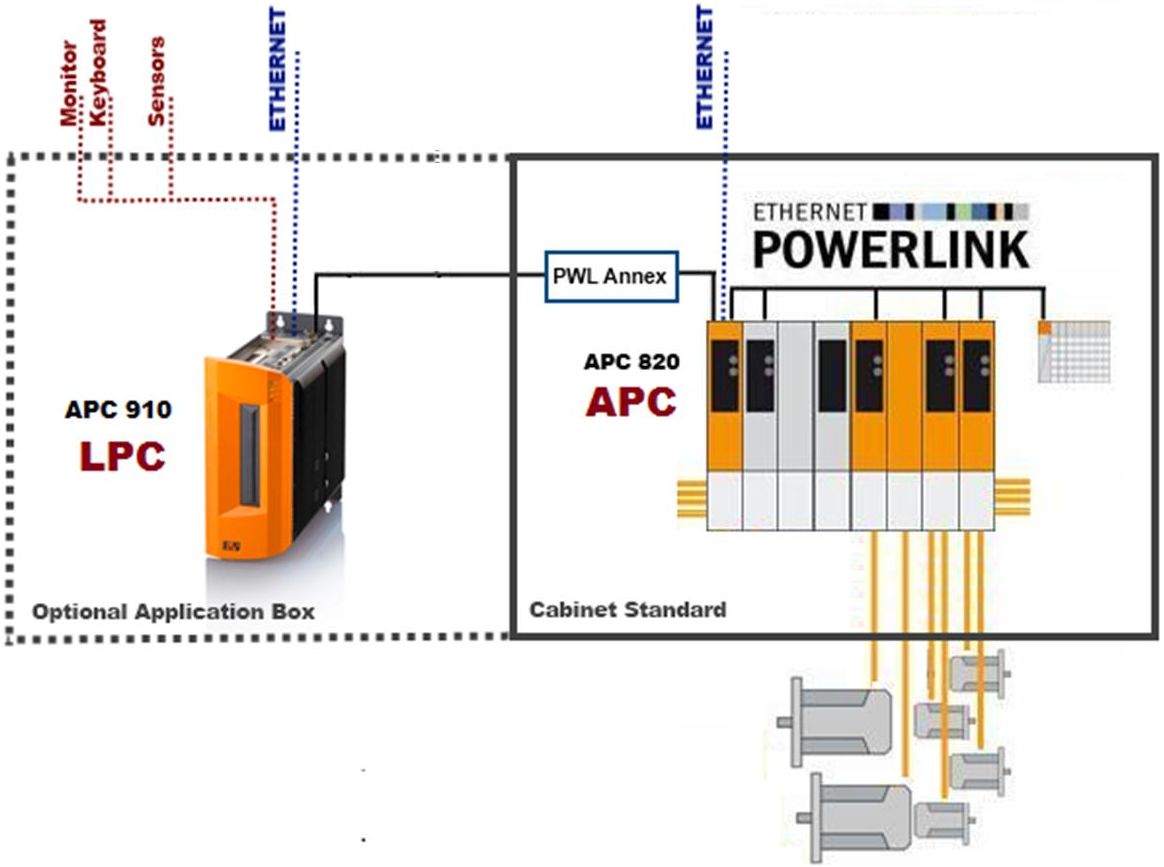
Graphic viewer: 3D visualizing of the robot movements on PC monitor

ROS Industrial interface: integration of Comau Robot with all the ROS modules developed in an academic or industrial scope

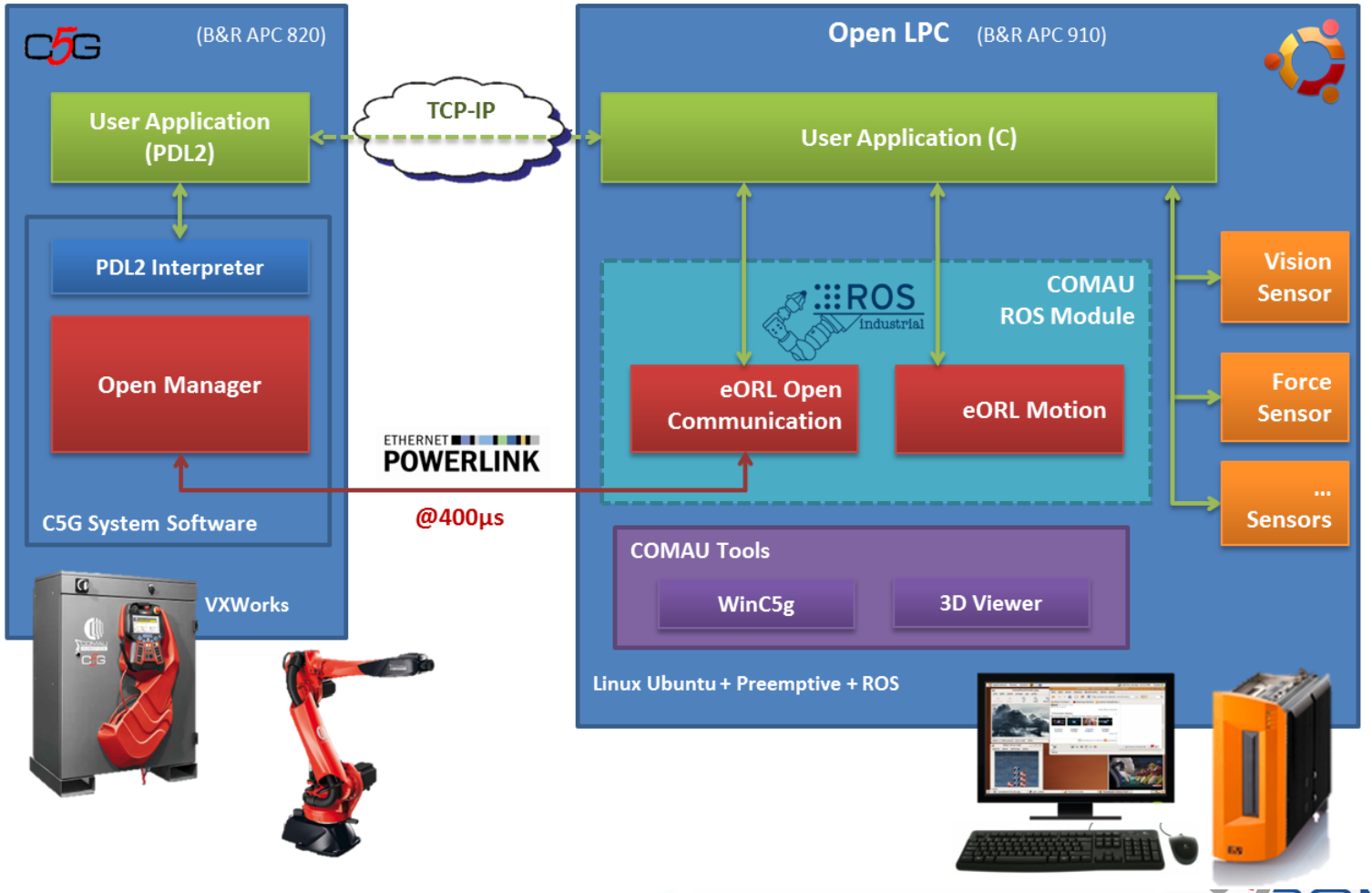
Control Function: Managing motion control algorithms inside C5G Open software the references of position, velocity or current provided by PC are checked before driving the robot

Simulator function: C5G Open can work also like a simulator testing PC application and working cycle of robot in a more safe condition

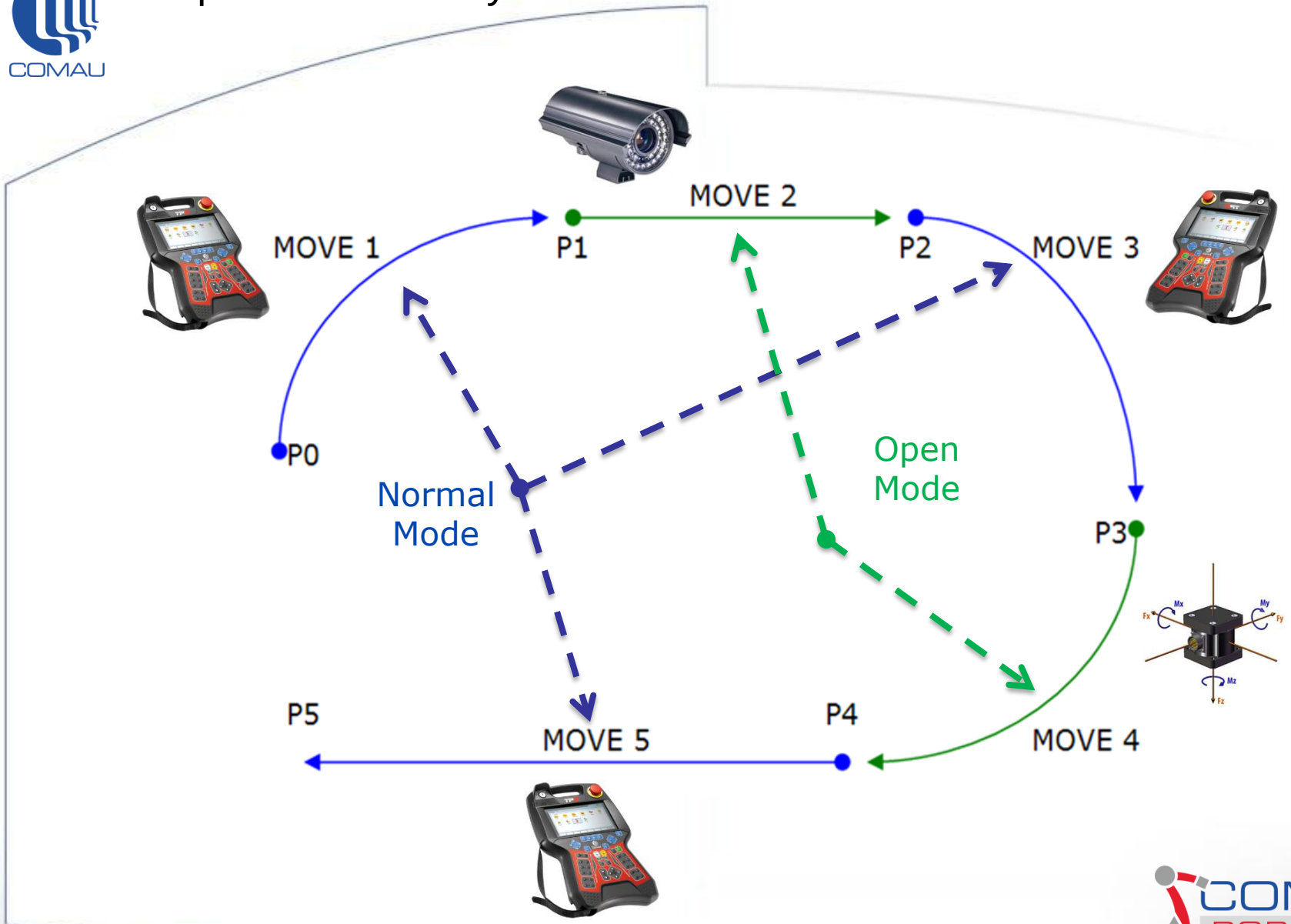
Hardware Architecture



Software Architecture



Open Functionality



Open on Web

- **Students**
  - Sharing works/tutorial
  - Supporting themselves
- **Researchers**
  - Sharing works/tutorial
  - Promote and advertise their activities

COMAU Open Community

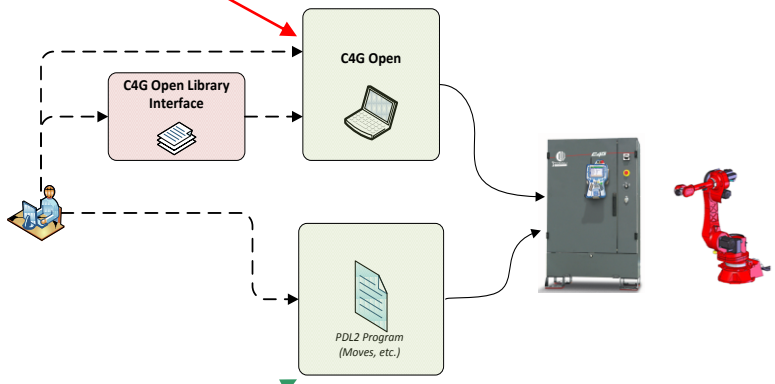
- **Integrators and Companies**
  - Looking for support
  - Finding new ideas
  - Making self advertisement
  - Finding partners, consultants and know-how
- **COMAU**
  - Experiences
  - Good advertisement
  - Support for technical assistance

4 Everyone

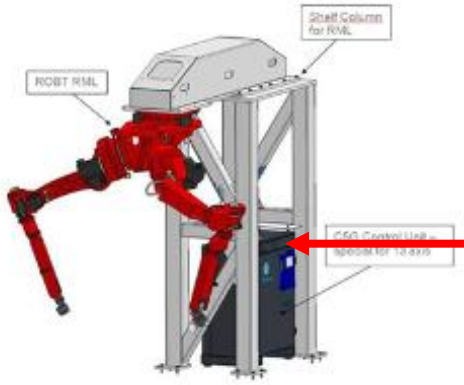
Sharing is caring!

ORL (OPEN Real Robot Library) Library

- **General architecture with C5G Open & ORL**
  - **C++ Program:**
    - This code acts as a multithreaded application which enables the user to input values of joint positions or Cartesian positions in order to set the robot movement.
    - One thread manages the interface for input the positions/joint positions
    - One thread manages the communication with the C5G Open Control (acting like the server waiting in order to accept connections from the C5G Controller)
  - **PDL2 Program:**
    - This code serves as the controller in order to command the C5G Open modality change when some state changes occur in the state machine. Written in PDL2 and running directly on the C5G Controller.



Service oriented architecture concept



RML service

DataAccess

ROS interface

ROS message: Read/ write to database

ROS message: Get HUMAN service commands

X-act Database

DataAccess

DataAccess

Human service

ROS message: Read/ write to database

ROS message: Send recognized voice command

ROS message: Write in DB recognized voice command

ROS message: Send recognized gesture command

ROS message: Write in DB recognized gesture command

DataAccess

DataAccess

Voice engine service

Kinect service

Storage area

Why to choose Service Oriented architecture?

The **advantages** are:

•**Extensibility**, (integration of new services, independently of programming languages)

•**Convenient structure** for developing new modules

•**Collaboration** between program developers for every different service/resource, as the communication is managed through the ROS messages

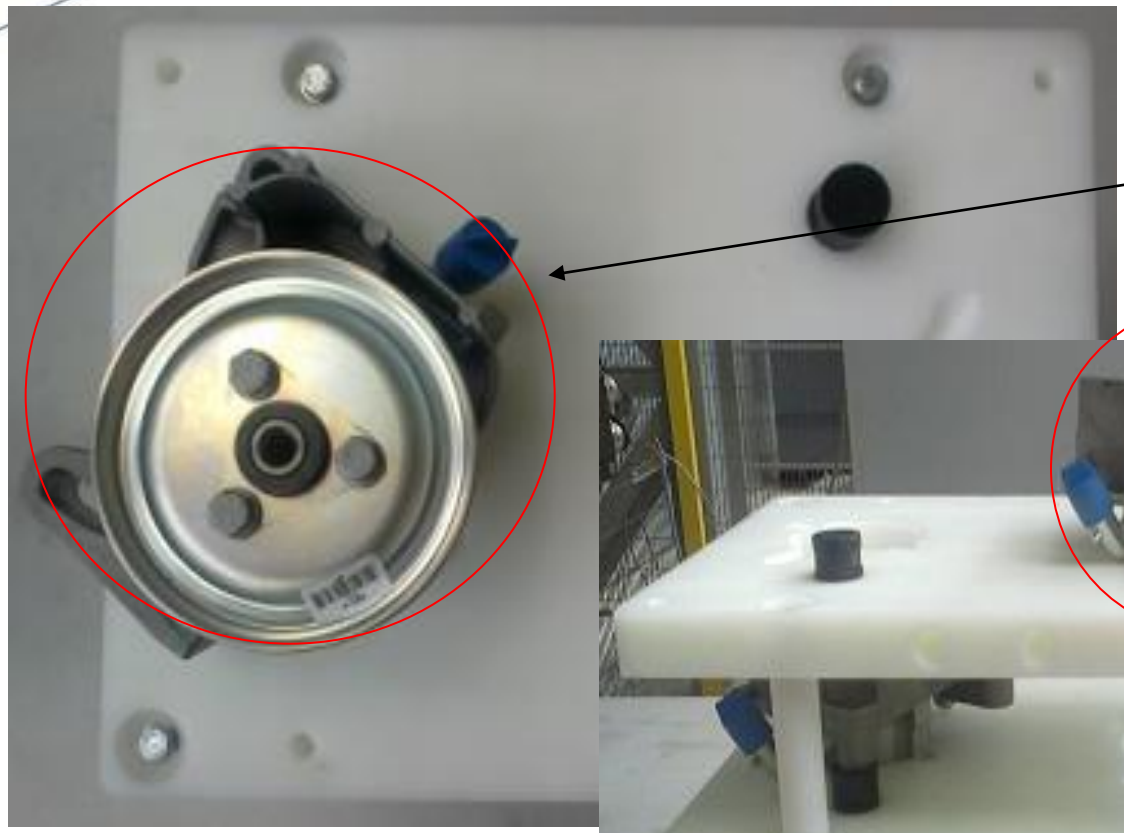
• **Decrease the development and integration time**, as multiple services can be supported from different developers

•**Free and open operating system (ROS),** able of supporting every relative architecture in Linux based environments

X-act project

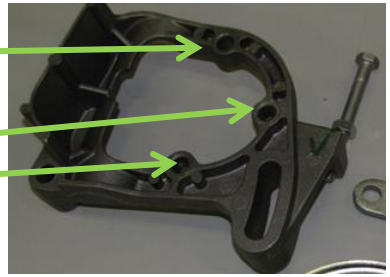
Hydraulic pump pre-assembly scenario

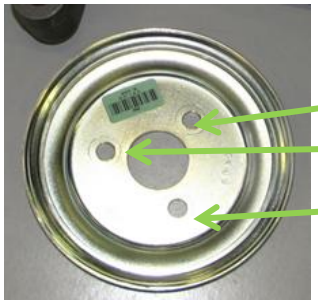
Hydraulic pump pre-assembly scenario layout

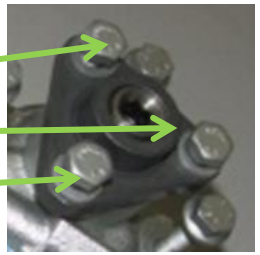


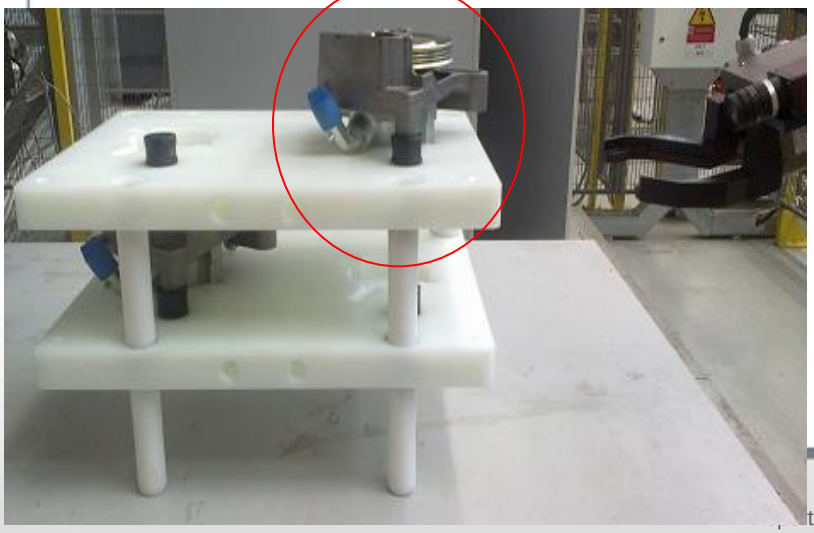
Hydraulic pump

Hydraulic pump components

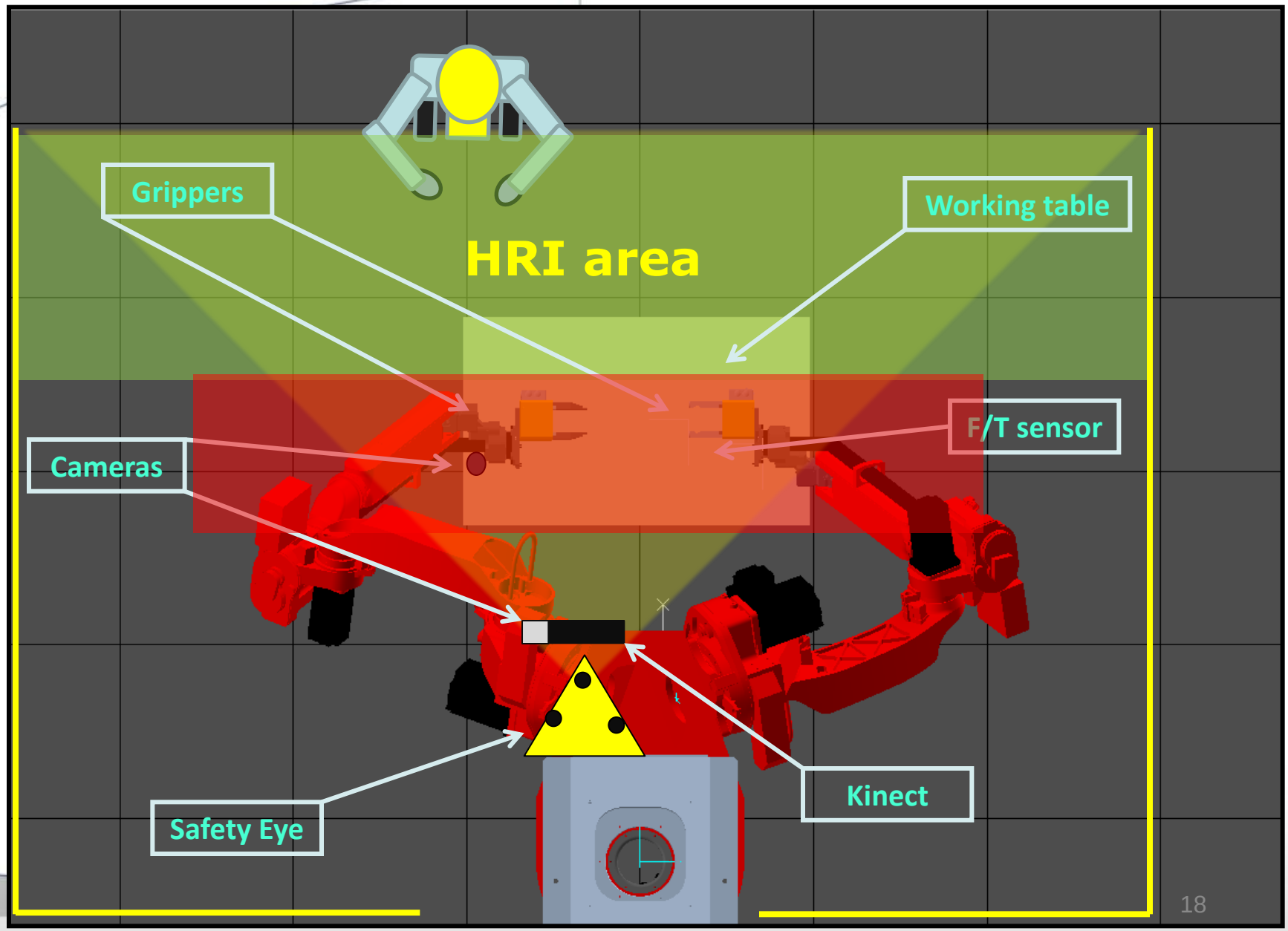








Hydraulic pump pre-assembly scenario layout



Hydraulic pump pre-assembly scenario layout

Hardware selection

Tray

Customized solutions

A tray has been designed and built in order to hold the base of pump permitting the stacking of several assembling parts.

Hydraulic pump pre-assembly scenario layout

Hardware selection

Gripper

Schunk PG70

- Recommended workpiece weight: 1kg
- Max gripping force: 200N
- Min gripping force: 30N
- One per each arm

F/T sensor

ATI FTN-GAMMA-SI 32-2.5

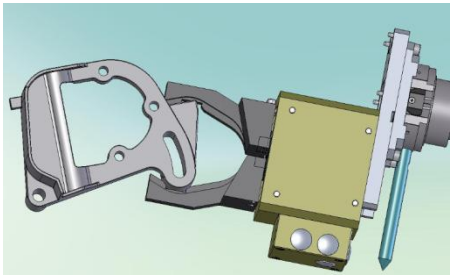
- Recommended : 2.5 kg

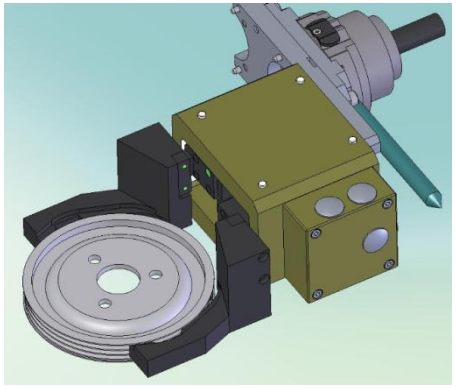
- force control on Comau on C5G

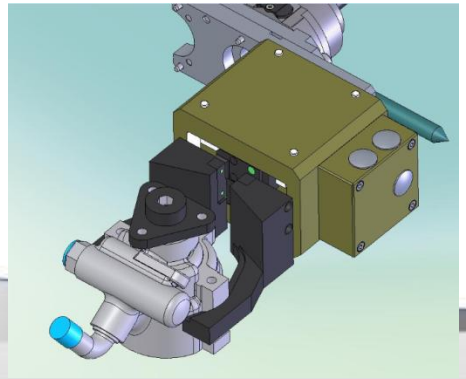
Hydraulic pump pre-assembly scenario layout

Hardware selection

Fingers







Customized solutions

Customized fingers have been designed and a first prototype is built in order to grasp all the parts. The two arms present two different fingers: this dual approach allows the execution of different tasks with dedicated features.

Hydraulic pump pre-assembly scenario layout

Hardware selection

Vision system

Allied Manta G-201 B

- Software: dedicated (visioning):
- Model: Manta G-201 B
- Sensor: Sony ICX274
- Resolution: 2 Mpixel
- Focal: 12 MM/23

Tattile

- Software:openCV
- Model: M0-XP
- Processore Intel Atom Z530 1.6GHz
- FPGA Altera Arria II GX 45K LE
- Resolution: 640x480/1024x768
- Focal: 12 MM/23

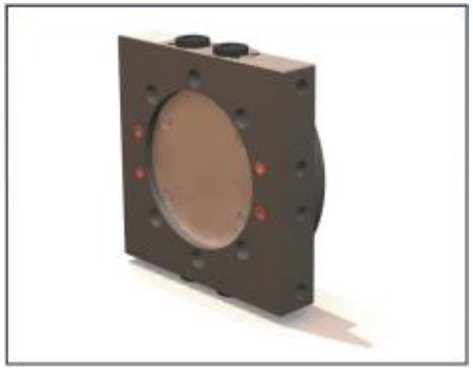
Hydraulic pump pre-assembly scenario layout

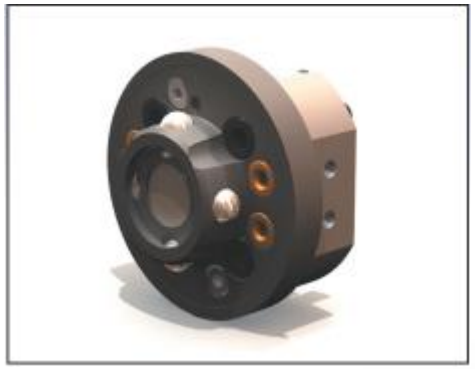
Hardware selection

Screwdriver

An industrial screwdriver has been bought and preliminar test has been executed. The screwdriver will be used in conjuction with a tool changer device in order to increase the flexibility of the system.

ESTIC ENRZ-TU003-Screwdriver





Hydraulic pump pre-assembly scenario layout

Hardware selection for HRI and safety

SafetyEYE

fenceless approach

- Integration/implementation

Kinect

Gesture recognizing and fenceless approach

- OPEN NI (driver)
- Point cloud for commands

MGD

Comau Manual Guidance device for easy programming

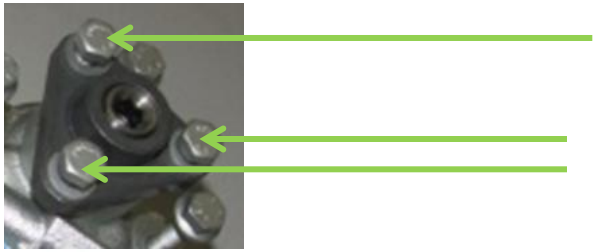
- One per each arm

Hydraulic pump pre-assembly scenario layout

Sequence of operations:

- All parts are on the working table
- Vision system detects all parts
- The Arm 1 grasps the first object (pump base) putting it into the tray

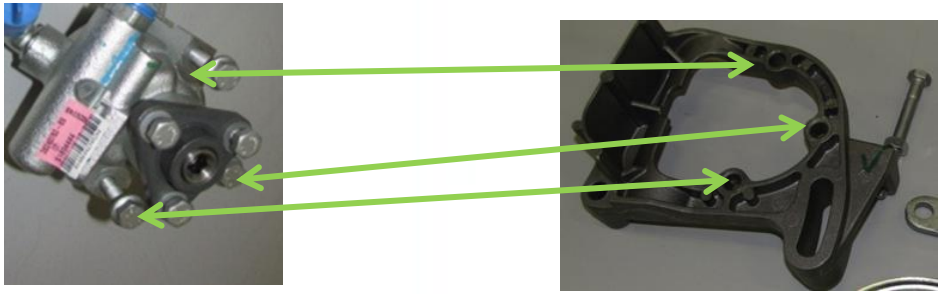
- Vision system detects the screw holes on the triangle of pump base orienting it in a appropriate way



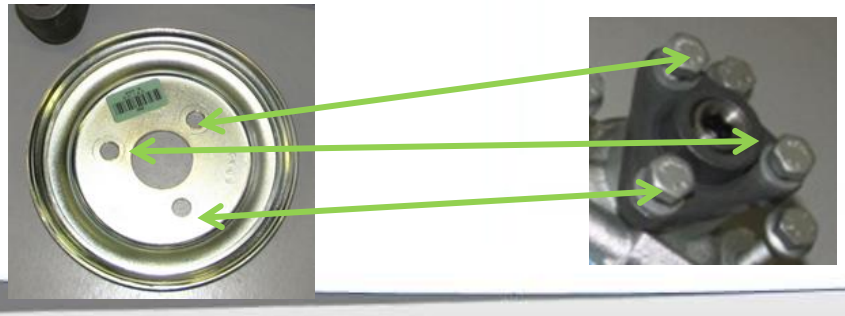
- The Arm 1 grasps the second object (steel cover)

Hydraulic pump pre-assembly scenario layout

- Vision system detects the screw holes on steel cover and Arm 1 orient it in order to align the holes with pump base

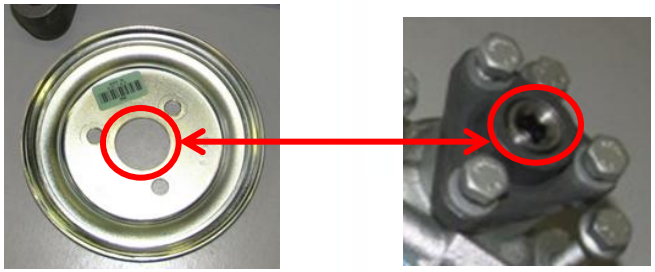


- Arm 2 Pick screws from the the customized support and fastens them
- Arm 1 grasps the third object (aluminum circle)
- Vision system detects the screw holes on the aluminum circle



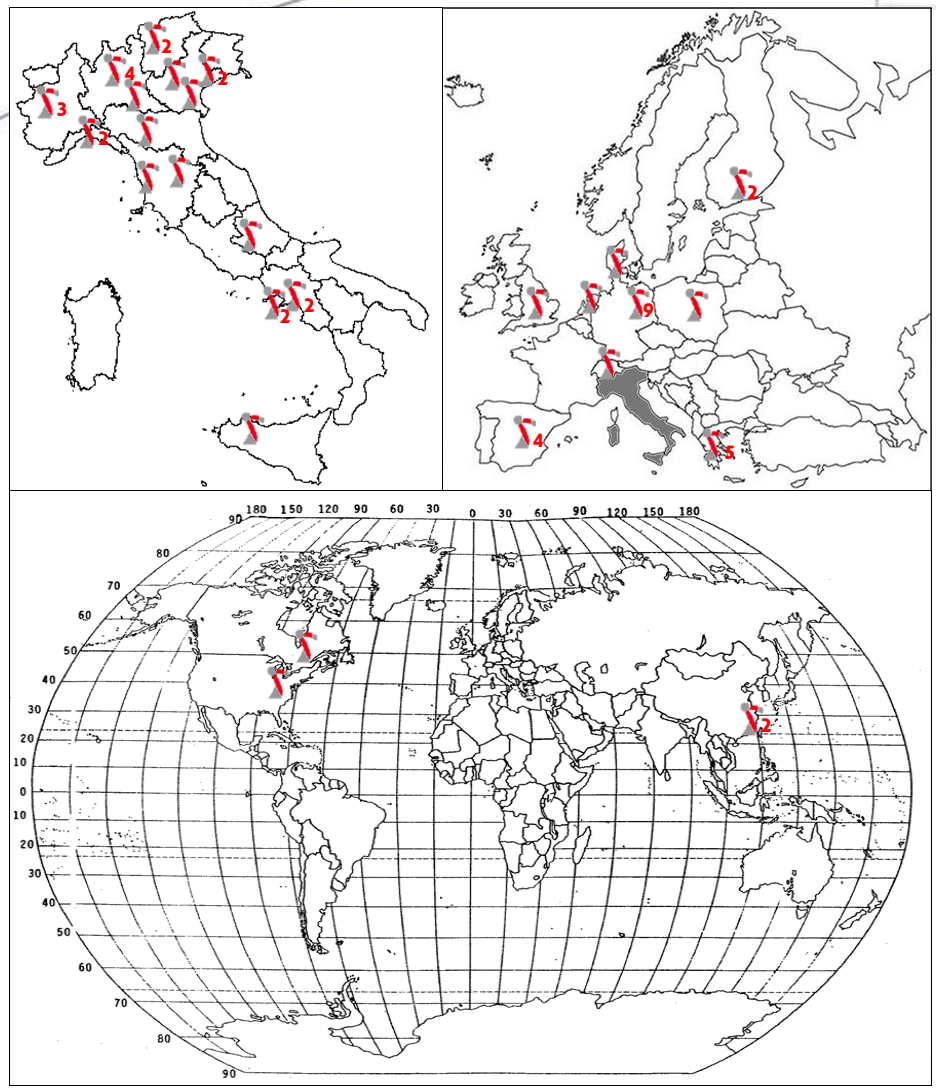
Hydraulic pump pre-assembly scenario layout

- Arm 1 orients it alligning the holes with triangle base taking advantage of F/T sensor to execute the task

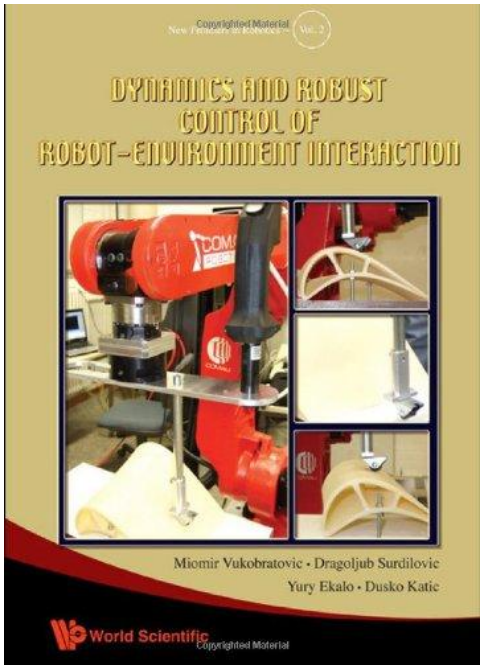


- Arm 2 Pick screws from the the customized support and fastens them

COMAU Open Control Diffusion



As example: Control of Robot-Environment interaction



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