ECHORD++

The European Coordination Hub for Open Robotics Development

WIRES

WIring Robotic SystEm for Switchgears
www-lar.deis.unibo.it/people/gpalli/WIRES/

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ECHORD++ Final Review Meeting

Barcelona, March 27th, 2019

Università degli Studi della Campania *Luigi Vanvitelli*

IEMA
Impianti Elettrici Macchine Automatiche

TUM

brl
Bristol Robotics Laboratory

UPC

BLUE OCEAN ROBOTICS
- for humans

cea

RURoBOTS
Cognitive Science at Work

SEVENTH FRAMEWORK PROGRAMME

Brief Experiment Description

The **WIRES** experiment aims at developing the basic tools and techniques for enabling the robotized switchgear wiring in the industrial scenario

- Switchgears are found in power generating stations and substations, commercial and institutional buildings, industrial plants, automatic machines, civil houses
- The production is characterized by large **variability** and **small production lots**
- **Automatic solutions** for switchgear wiring are **very limited**
- Reduced flexibility and programming **time** and **cost**
- **A strongly industry-oriented research and application** involving soft-object manipulation: a quite unexplored area

The wiring process is executed by human operators

Novelty/Objectives

A **software package** to extract the data from the switchgear design files and optimizing the wiring procedure and an **end effector** for electric cable connection
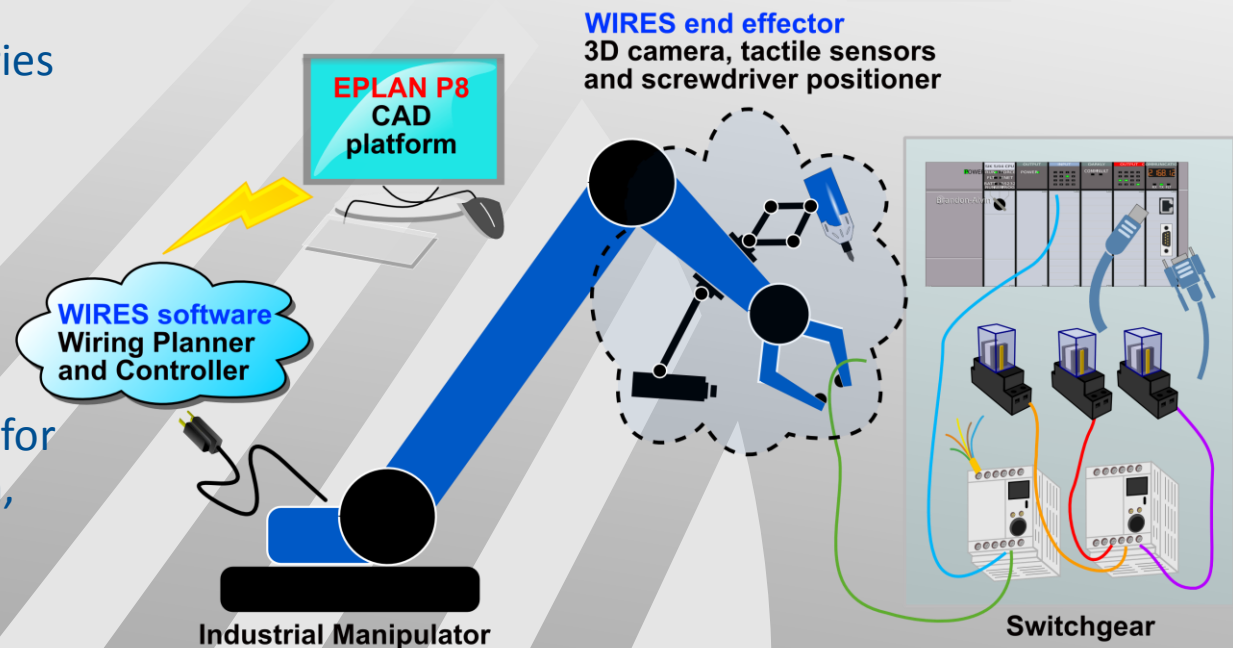
- **Software objective:**
  - o optimization of the wiring sequence
  - o planning robotic trajectories for wiring tasks

- **Hardware objective:**
  - o end effector for wiring operations
  - o with force/tactile sensors for detecting wire orientation, 3D camera and orientable screwdriver


The WIRES approach

EPLAN P8
CAD platform

WIRES end effector
3D camera, tactile sensors and screwdriver positioner

WIRES software
Wiring Planner and Controller

Industrial Manipulator

Switchgear
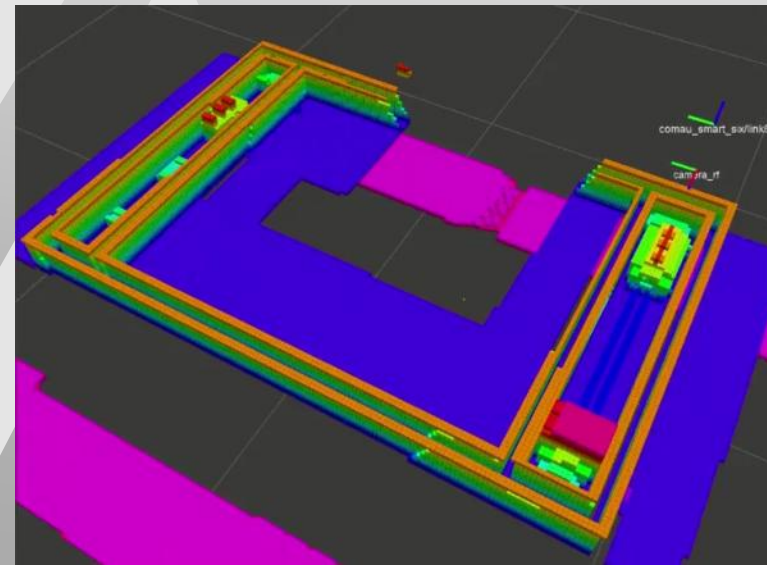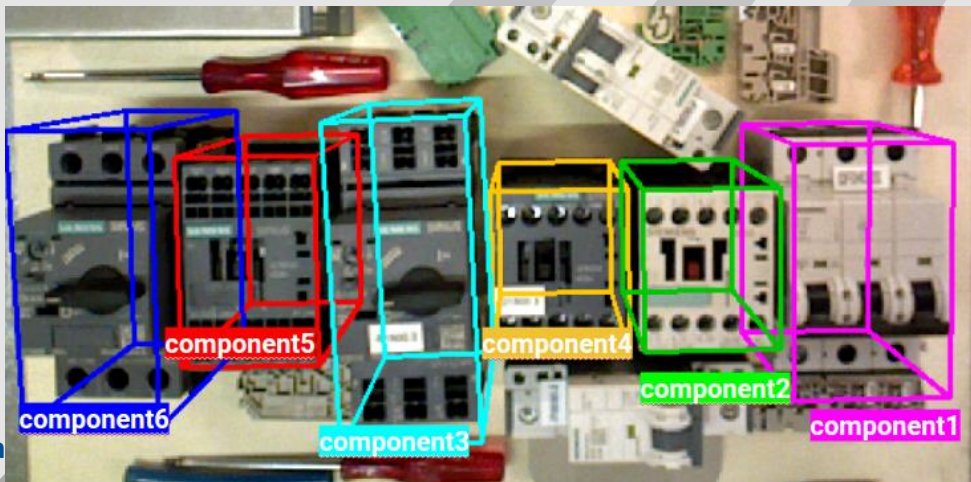
Task Implementation

- **Open problems**
  - poorly structured scenario
  - CAD data extraction
  - missing information about components
  - wire detection
  - wire grasping and manipulation
  - component detection
  - environment reconstruction
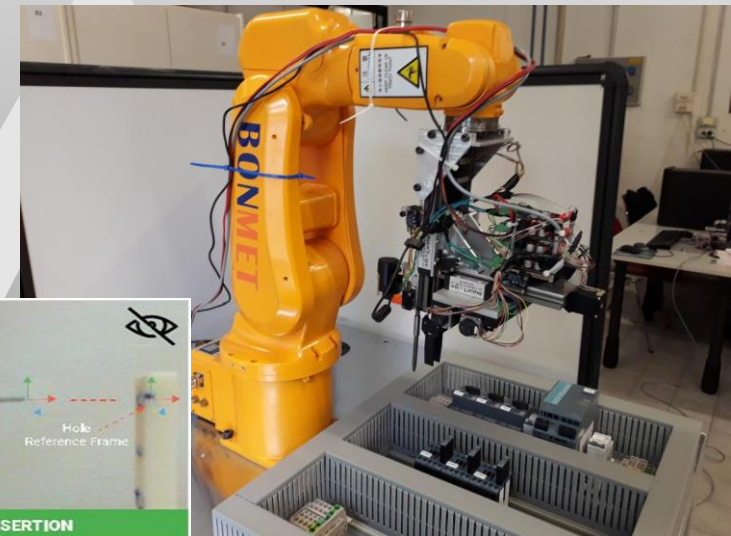 - wire tracking in crowd environments
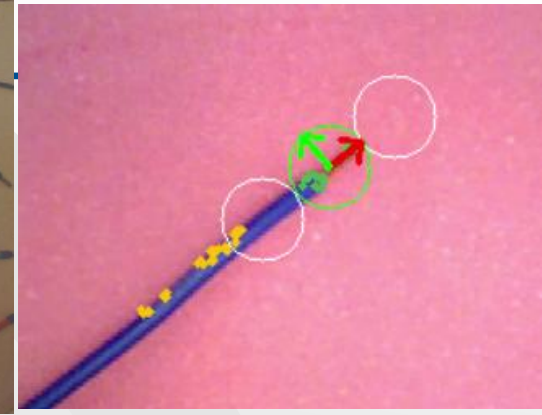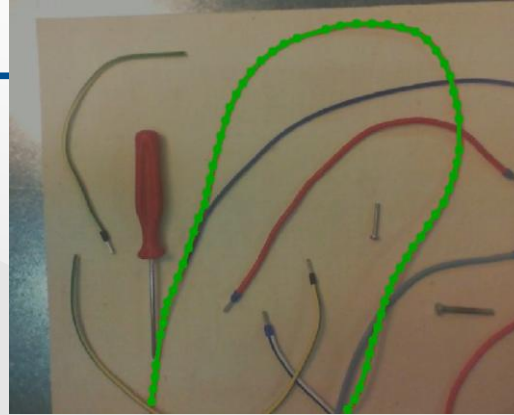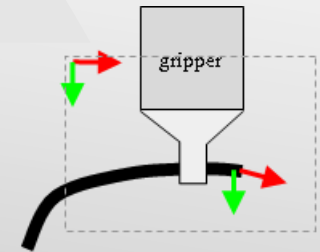
6-DOF Pose   3-DOF Pose

WIRES Demonstrator

- **The connection of each wire terminal consists in:**
  - wire detection
  - wire grasping
  - correction of wire position/orientation
  - insertion
- **All the system components have been integrated into a portable demonstrator**
  - first show at EPSOL opening ceremony in May 2018
  - Shown at Automatica 2018 in Munich in the ECHORD++ booth
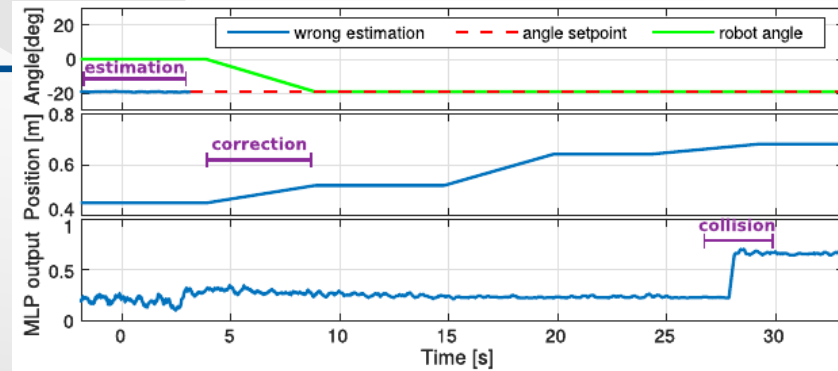- **A switchgear of reduced dimensions has been used**
  - video
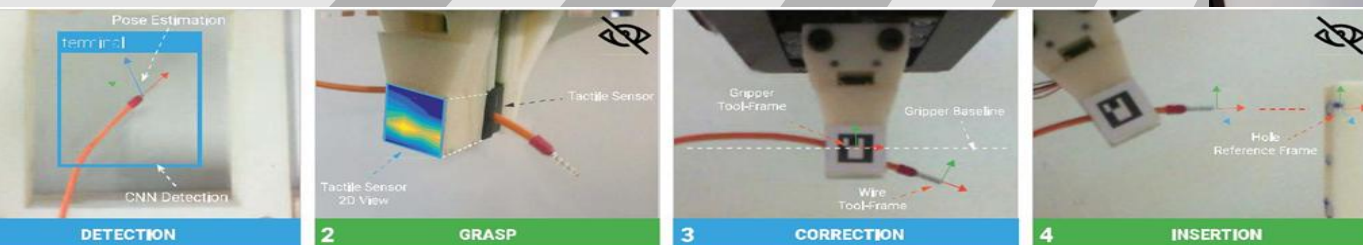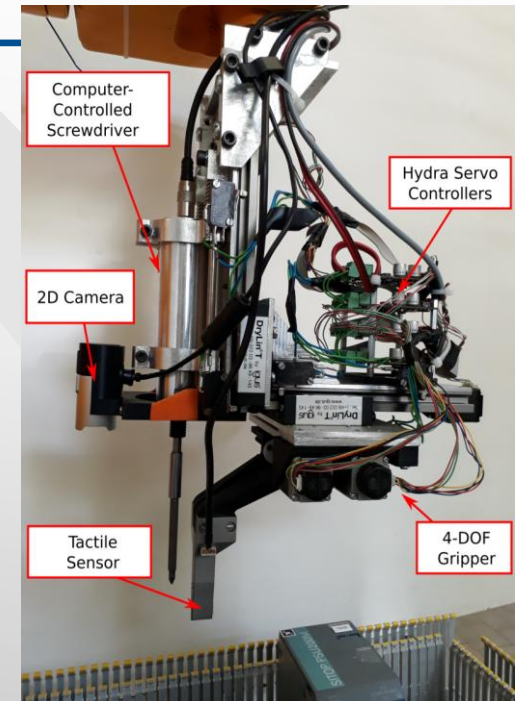
Results

- **A large set of experiments has been performed**
  - Large deviations from the nominal conditions have been checked
- **A 95% success rate has been achieved over a reasonable working region**

$$c = \begin{cases} 0, & \text{Position} > 0.65 \wedge \text{MLP output} > 0.5 \\ 1, & \text{Position} > 0.65 \wedge \text{MLP output} < 0.5 \end{cases}$$

| #	m [deg]	d [mm]	c	#	m [deg]	d [mm]	c
1	-5.7	48.0	1	1	13.5	27.0	1
2	-1.0	32.5	1	2	-20.3	30.0	1
3	4.0	38.9	1	3	4.6	29.4	1
4	-2.9	27.6	1	4	4.0	30.0	1
5	27.5	46.5	1	5	-12.4	29.0	1
6	-32.6	40.6	0	6	23.3	43.0	0
7	-15.6	38.5	1	7	-19.8	41.0	1
8	12.4	39.4	1	8	0.6	40.0	1
9	14.0	29.5	1	9	24.2	48.0	0
10	10.8	24.4	0	10	21.8	52.0	1
11	46.4	56.0	0	11	52.9	56.0	0
12	42.9	60.9	1	12	7.4	35.6	1
13	-28.4	45.3	0	13	47.5	52.0	1
14	41.3	65.9	0	14	58.6	95.0	0
15	33.0	39.0	1	15	44.7	69.2	0

(a)
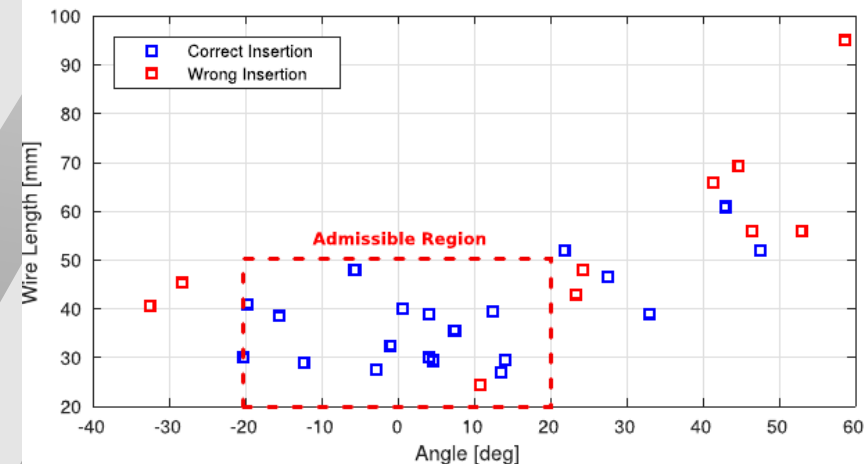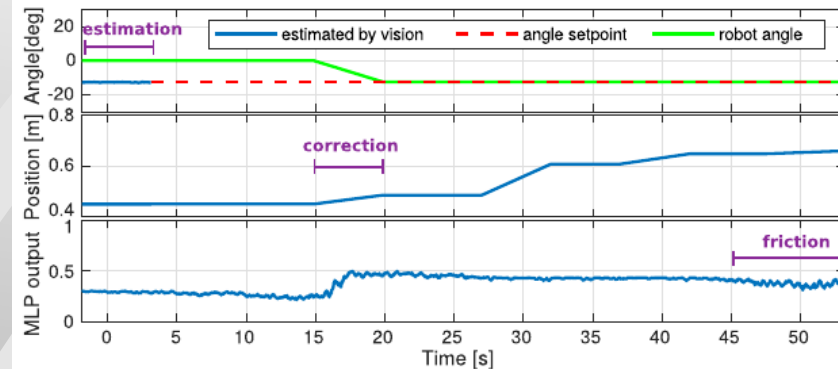
Summary

- **Being part of ECHORD++**
  - made cooperation with industries possible to investigate a challenging problem
  - increased visibility thanks to provided services
  - gave access to booth in big fairs e.g. AUTOMATICA

- **Outcomes exploitation**
  - IEMA funded a research grant to put WIRES results in production to solve production related problems
  - creation of a spin-off to industrialize and commercialize the robot-based wiring and testing solution
  - joint participation to other research grants at regional and EU level
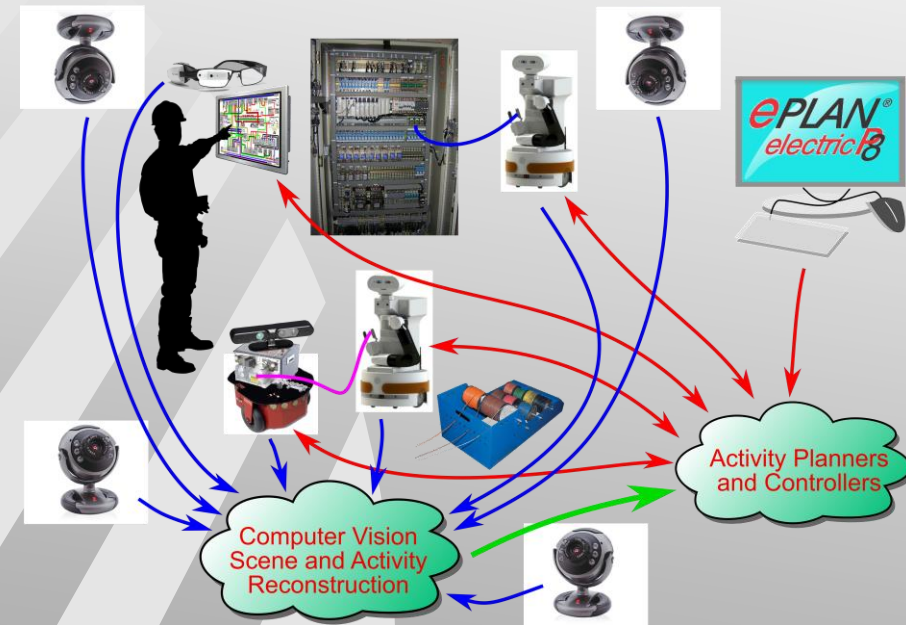
Thank you for your attention!!!

Questions?