AugmentX – Robots and Cobots

Location: R&MM @VUB

Introduction

Scope

This document is intended as a **thematic information sheet** on infrastructure of the **R&MM core lab** facility. Consequently this document only covers elements that have the VUB R&MM facility as default location and fit in the scope "**Cobots and Robots**".

There are some devices that could belong to multiple thematic information sheets. The impact measurement set form Pilz, is often used to assess the impact of a collision between a cobot and a person. However, this device is considered in the thematic information sheet "Cognitive and Physical assessment" and not here.

For questions relating to the infrastructure presented on this information sheet, please contact us via AugmentX@flandersmake.be .

Robots

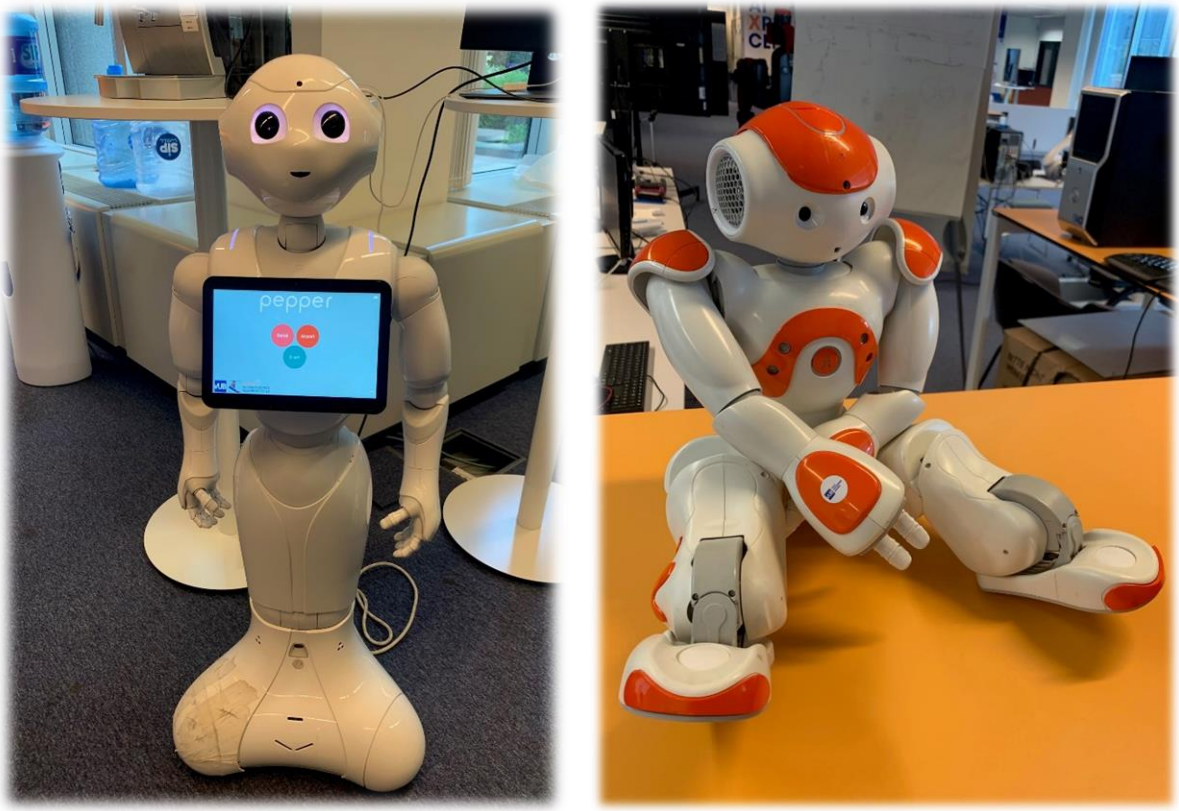

Fig1: left Pepper, right NAO

AugmentX – Robots and Cobots

AldeBaran - Pepper

Pepper (see Figure 1 left) is a social robot that is able to recognize faces and basic human emotions. Pepper was optimized for human interaction and is able to engage with people through conversation and its touch screen. The main features of pepper are listed in the table below:

Degrees of freedom	20
Speech recognition	15 languages
Perception modules	Recognizes and interacts with persons
Interaction	Through speech or touch screen
Sensors	Touch sensors – Microphone – infrared sensor – IMU – Bumper – 2D and 3D camera
Size	120cm
Navigation	Autonomous omnidirectional
Connectivity	Ethernet

Pepper is fully programmable with a graphical interface, or directly with the Software Development Kit (SDK) and coding tools:

- Choregraphe: an IDE (Integrated Development Environment) to program with an easy drag-and-drop interface and with Python.
- Software Development Kit (SDK): gives access to the complete set of features of Pepper and NAO. It is available in Python and C++.
- Pepper SDK for Android: an entirely integrated plugin for Android Studio to add compatibility with Pepper to Android Applications and develop in Java or Kotlin.

AldeBaran - NAO

NAO (see figure 1 right) is used as an assistant by companies to welcome, inform and entertain visitors. NAO is an interesting platform for research in social interaction. The main features of NAO are listed in the table below:

Degrees of freedom	25
Speech recognition	20 languages
Perception modules	Recognizes and interacts with persons
Interaction	Through speech or touch screen
Sensors	7 Touch sensors – 4 directional microphone – Sonar – IMU – 2D camera
Size	58cm
Navigation	Autonomous omnidirectional

Connectivity	Ethernet

NAO shares the same features w.r.t being fully programmable as Pepper (see previous paragraph) .

Cobots

UR16e

The Universal Robots UR16e (see Fig2.a and Fig2.b) delivers an impressive 16kg of payload within a small footprint. It is ideal for material handling, packaging, screw and nut driving applications. This powerhouse robot allows for heavier end of arm tooling and multi-part handling, and is especially useful for achieving shorter cycle times.
Key metrics of the UR16e are the reach of 90mm, the payload of 16kg, the footprint of 190mm and the weight of 33.1 kg (without drivers). The robotic arm provides six actuated axis. In addition to the torque sensing capabilities for each axis (basic feature of cobots), the cobot features a 6 d.o.f. sensor at the end effector fixation.
The CB5 controller (the new CB3) is delivered with a 12 inch touchscreen which is the control panel for configuration and also allows it to optionally install additional software packages. The graphical Polyscope environment enables it to integrate additional sensors or grippers. Form a software point of view, ROS drivers are readily available enabling a smooth and quick integration in cobot demonstrators. The UR16e is compatible with diverse gripper providers such as roboticq and onrobot. Besides grippers, there are many other tools that can be connected to the cobot. The following link provides a list of compatible extensions with the UR16e . The tools range over 3D scanners, cameras, barcode readers end-effectors, grippers, specialised actuators to software packages, and standard protocols.

AugmentX – Robots and Cobots

Fig 2.a: UR16e

Fig 2.b: Controller CB5

In the table below, some metrics are listed.

Payload	kg	16
Reach	mm	900
Robots mass	kg	33
IP		54 - 44
Axes		6
Repeatability	±mm	0.05
J1 speed / range	°/s - ±°	120 – 360
J2 speed / range	°/s - ±°	120 – 360
J3 speed / range	°/s - ±°	180 – 360
J4 speed / range	°/s - ±°	180 – 360
J5 speed / range	°/s - ±°	180 – 360
J6 speed / range	°/s - ±°	180 – 360
Footprint diameter	mm	190
Force sensing Precision	N	5
Force sensing Range	N	160
Links		Link

AugmentX – Robots and Cobots

FLANDERS MAKE
DRIVING INNOVATION IN MANUFACTURING

UR10e

The UR10e is an extraordinarily versatile collaborative industrial robot, delivering both high payload (12.5 kg) lift and long reach (1300 mm) which makes it well suited for a wide range of applications in machine tending, palletizing, and packaging.
The robotic arm provides six actuated axis. In addition to the torque sensing capabilities for each axis (basic feature of all cobots), the cobot features a 6 d.o.f. sensor at the end effector fixation.
The UR10eis very similar to the UR16e and w.r.t the software, features the same functionality as provided by the UR16e.

In the table below, some important metrics are listed.

Payload	kg	12.5
Reach	mm	1300
Robots mass	kg	33,5
IP		54 - 44
Axes		6
Repeatability	±mm	0.05
J1 speed / range	°/s - ±°	120 – 360
J2 speed / range	°/s - ±°	120 – 360
J3 speed / range	°/s - ±°	180 – 360
J4 speed / range	°/s - ±°	180 – 360
J5 speed / range	°/s - ±°	180 – 360
J6 speed / range	°/s - ±°	180 – 360
Footprint diameter	mm	190
Force sensing Precision	N	5
Force sensing Range	N	100
Links		Link

AugmentX – Robots and Cobots

Franka Panda

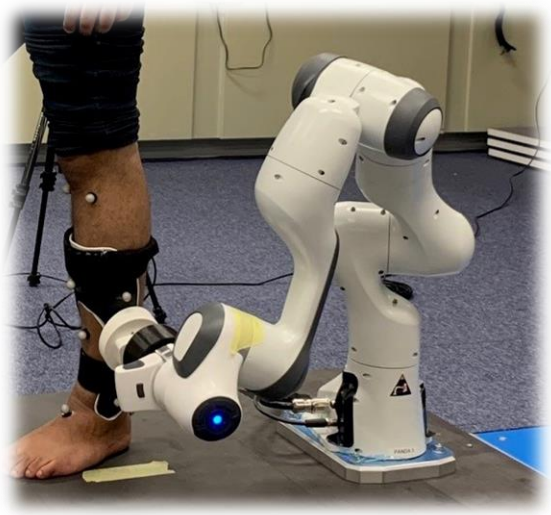

Fig 3.a: Franka Panda

Fig 3.b: Franka Panda

Franka Research 3 's robot system includes the Arm and its control power electronics. The force sensitive Arm features 7 DOF with torque sensors at each joint, industrial-grade pose repeatability of +/- 0.1 mm. It comes with a payload of 3 kg, a reach of 855 mm.
The Franka Control Interface (FCI) is ideal to explore low-level programming and control schemes, providing the current status of the robot and enabling torque control, at 1 kHz. On top of the C++ interface libfranka, integration with the popular ecosystems ROS, ROS2 and MATLAB & Simulink are available.
Desk is the browser-based user interface that offers quick robot control options, and where Apps can be dragged and dropped into a sequence to create entire tasks in no time. Ideal for rapid prototyping of robot behaviour, setup of experiments, simple human-robot interaction studies and demos.

In the table below, some important metrics are listed.

Payload	kg	3
Reach		855
Robots mass	kg	17.8
IP		40
Axes		7
Repeatability	±mm	0.1
J1 speed / range	°/s - ±°	150 – 166
J2 speed / range	°/s - ±°	150 – 105
J3 speed / range	°/s - ±°	150 – ?
J4 speed / range	°/s - ±°	150 – 90

J5 speed / range	°/s - ±°	301 – 165
J6 speed / range	°/s - ±°	301 – 145
J7 speed / range	°/s - ±°	301 – 175
Force sensing Precision	N	5
Guiding force	N	2.5
Installation		upright / horizontal
Translational stiffness	N/m	10-3000
Rotational stiffness	Nm/rad	1-300
Links		Link

Kuka iiwa14 medical

The KUKA Sunrise Cabinet has a compact, light-weight yet robust design while offering the user reliability and high performance. The size of the controller also guarantees flexibility, as it can be installed either in a 19" rack or as a stand-alone device. It is truly an all-rounder with integrated sensor processing and everything for the entire system united in a single controller. Software-based solutions have replaced the significant amount of hardware components, cables, and connectors providing low maintenance. The tough KUKA smartPAD enables a simple, user interface to control the KUKA Sunrise cabinet and iiwa 14. The force sensing capability is very qualitative however, it is only based on torque sensing.
The medical version omits the internal pressure tubing in order to have clean outside surfaces that are easily cleaned.
Most of the software has been written in JAVA. Communication with the cobot takes place through ethernet port via the TCP-IP protocol or the dedicated analogue and digital inputs. Consequently, integration in opensource research platforms such as ROS is difficult or not possible. On the other hand the software is extremely robust.

Fig 4.a: KUKA iiwa14 (medical)

Fig 4.b: Sunrise Cabinet and Smart PAD

In the table below some key metrics are listed.

Payload	kg	14
Reach	mm	820
Robots mass	kg	30
IP		54
Axes		7
Repeatability	±mm	0.1
J1 speed / range	°/s - ±°	85 - 170
J2 speed / range	°/s - ±°	85 - 120
J3 speed / range	°/s - ±°	100 - 170
J4 speed / range	°/s - ±°	75 - 120
J5 speed / range	°/s - ±°	130 - 170
J6 speed / range	°/s - ±°	135 - 120
Footprint diameter	mm	136
Touch Screen Size	“	8.4
Links		Link

Baxter – Rethink

Baxter (2012 – discontinued) is a versatile manufacturing robot. Its cameras and force-sensing actuators let it adapt to changes in the environment, and a user can program a new task simply by moving its arms around. An extensive SDK is available and numerous resources w.r.t. controlling Baxter via ROS are available.

Fig 5.a: Baxter

Fig 5.b: close up of the hand

Baxter is equipped with active and passive safety systems and a user-friendly control interface. It is able to control movements based on vision and force sensing.

In the table below some key metrics are listed.

Payload	kg	14
Reach	mm	820
Robots mass	kg	30
IP		54
Axes		7
Repeatability	±mm	0.1
Weight (excluding the pedestal)	kg	75
Span (when stretched out)	cm	260
Height (excluding pedestal)	cm	94
Length	cm	37
Degrees of Freedom (dof)		16 (Arm: 7 DoF x 2; Head: 2 DoF)
Sensors		Five cameras (one in the head, two in the chest, and one in each forearm). Force sensing based on series elastic actuators. Head with sonar array for detecting humans moving close by.
Actuators		Series elastic actuators with brushless DC motors, metal and plastic gearboxes, and custom spring element.

Linear cobot track LMK16-ALU-B from Cobotracks

The linear cobot track can easily be used with the UR16e. The device fully integrates with UR software where it effectively becomes a seventh axis.

Fig 6: Cobotrack LMK16-ALU-B

The main specs of the linear track are listed below:

Compatible cobot type	UR16e
Max stroke	105 mm
Max speed	250 mm/s
Repeatability	0.1 mm
Ambient temperature	-10 °C to 60°C
Electric supply	3 x 380 V
Weight	40.5 kg

Depth camera Pick it

The pick it 3D camera easily interfaces with the UR16 via the URCap (UR app) and ROS drivers are readily available. The Pick it can identify independent objects in bin picking applications.

Fig 7: Pickit camera M-HD

The main specs of the Pick it M-HD are listed below:

Method	Structured light
Capturing time	200-1000 ms
Resolution	1920 x 1200
Weight	2000 g
Connection to PC	M12-8 (USB) - USB3
Connection to robot	TCP/IP over Ethernet
Min Height	600 mm
Min Field of View	250 mm x 420 mm
Max Height	2000 mm
Max Field of View	870 mm x 1300 mm

Grippers

We have several pneumatic and electric grippers available. These gripers need at least two or more points of contact in order to hold an object. We also have several electromagnets and vacuum nozzles available that can get by with only one point of contact. Grippers are often custom built. Some of the more generic electric grippers are described below.

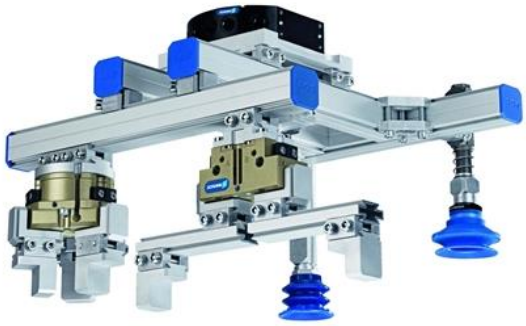

Fig 8.a: Pneumatique gripper and vacuum cups

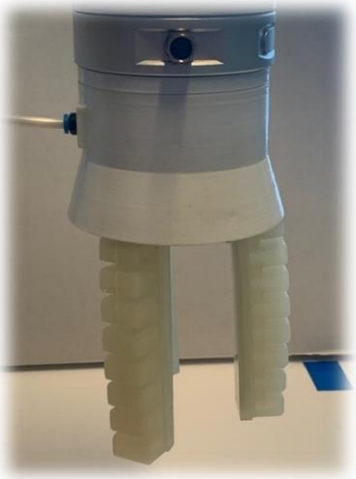

Fig 8.b: Self-healing pneumatic grippers

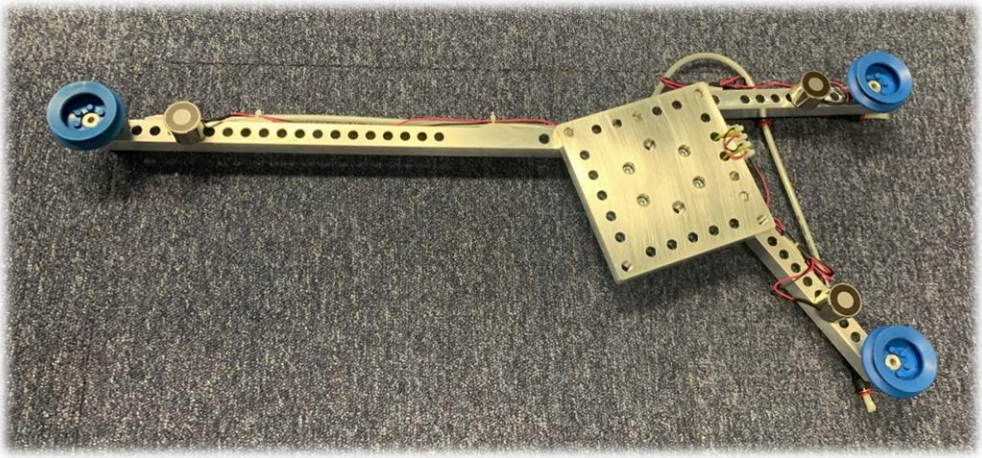

Fig 8.c: Hybrid gripper (electromagnet and suction cups)

Three finger gripper – Robotic

The Robotiq, three finger gripper is equipped with, three adaptive fingers. The 3-Finger gripper is a good option due to the versatility and flexibility. It picks up any object of any shape. Two of the three fingers have the extra degree of freedom and can twist towards each other.

The Gripper features four modes: pinch, wide, scissor and basic mode. One can control and get torque feedback from every dof separately. With the gripper URCap, it is easy to control the gripper and very straight forward. Also, the ROS drivers are readily available.
The Gripper can hold 2.5 kg with its finger tips and 10 kg encompassing grip. The object diameter for encompassing is 20 to 155 mm. For maximal loads however, we advise the limit this range to object diameters ranging between 40 to 100 mm.

Fig 9: Robitiq three finger gripper

The main specs of the Robitiq three finger gripper are listed below:

Compliant	electronically controlled
DOF	8
Grasping force	30-70 N
Max recommended payload	10 kg
Max fingertip payload	2.5 kg
Weight	2.33 kg

Two finger gripper – Emika

Fig 10: Emika two finger gripper

This gripper enables the Panda robot arm to grab and lift a large number of objects. It can be controlled and programmed via the user interface "Desk" and FCI (C++, ROS). The gripper features:

- Fingers tips can easily be exchanged;

AugmentX – Robots and Cobots

FLANDERS MAKE
DRIVING INNOVATION IN MANUFACTURING

- a gripping force of 70 N (continuous, peaks up to 140N);
- a speed 50mm/s (per finger);
- the maximal opening of the gripper is 80mm.
- a gripper weight of 0,7kg

Interested?

Contact AugmentX@Flandersmake.be for more information.