ISTITUTO ITALIANO
DI TECNOLOGIA
HUMANOIDS AND HUMAN
CENTERED MECHATRONICS

Università
di Genova

Unlocking the Potential of the Nicla Vision Board with ROS / ROS 2

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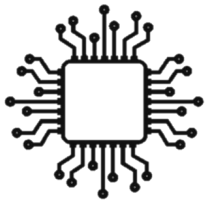

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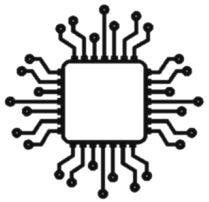

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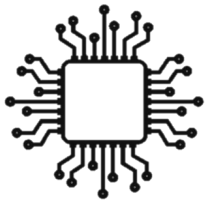

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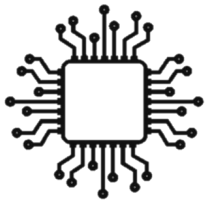

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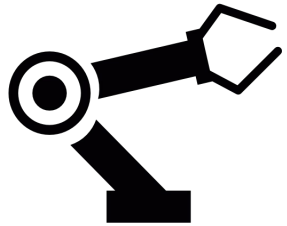
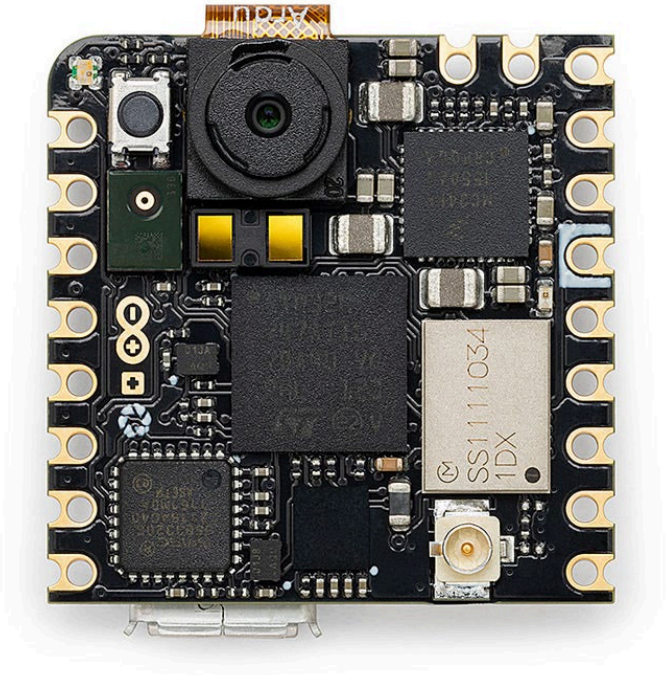


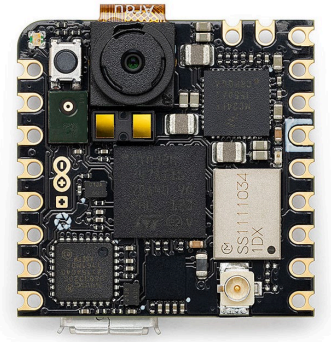
Integration and **demonstration** of the board potentiality, as the DAGANA end-effector sensing module ("**eye/ear-in-hand**").

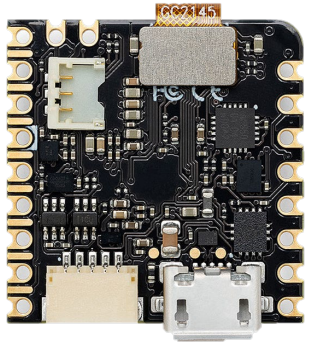
Hardware



Arduino Nicla Vision

- Compact smart sensing module 22.86 x 22.86 mm
- Processor
  - STM32H747AII6 Dual Arm® Cortex® M7/M4 IC
- Sensors:
  - 2MP RGB Camera
  - IMU Sensor
  - Microphone
  - Distance/ToF Sensor
- Connectivity
  - Wi-Fi and Bluetooth
- Cheap (~115€)





Software Architecture

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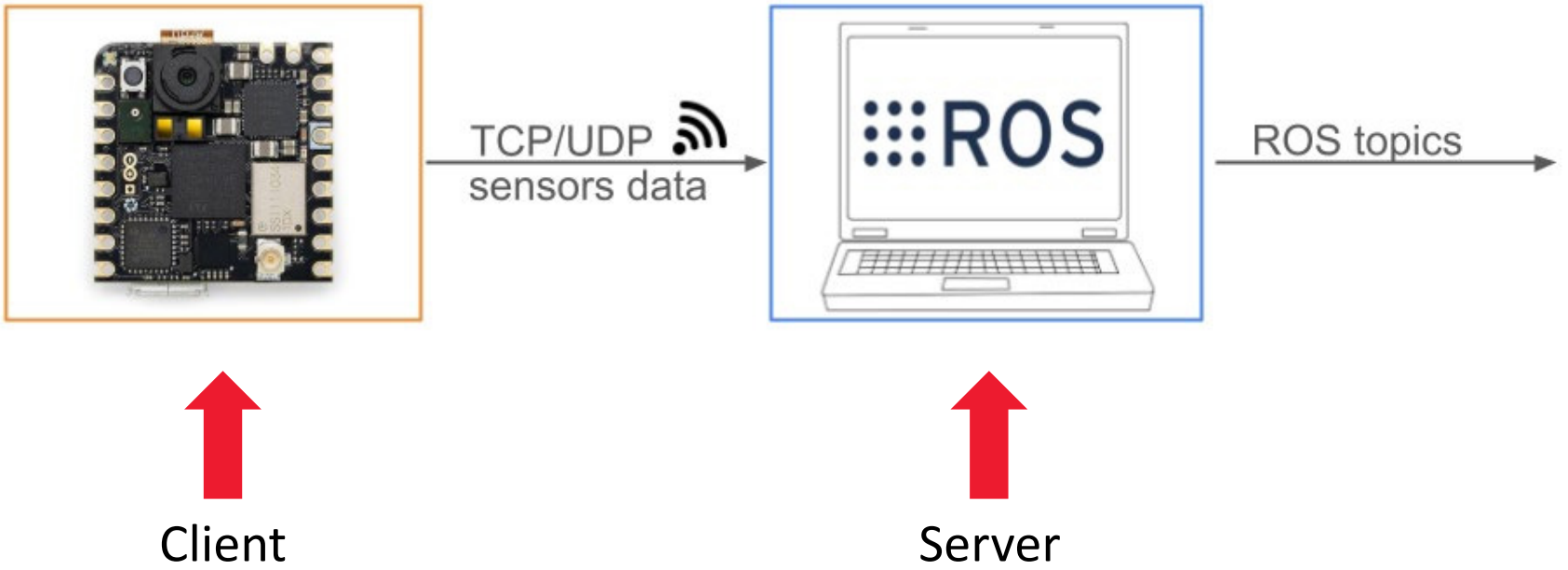

Nicla Driver

- Arduino & MicroPhython drivers available
  - MicroPython not maintened anymore
- All sensors integrated
- The driver acts as a TCP/UDP Client in the architecture
- Communication protocol

HEADER			PAYLOAD
Packet size	Timestamp	Sensor type	Data

Package `nicla_vision_ros`

- A TCP/UDP Server establishes a connection with the Client running on Nicla and:
  - deserializes the messages received
  - disposes each data and
  - streams them to the ROS topic corresponding to its sensor type.

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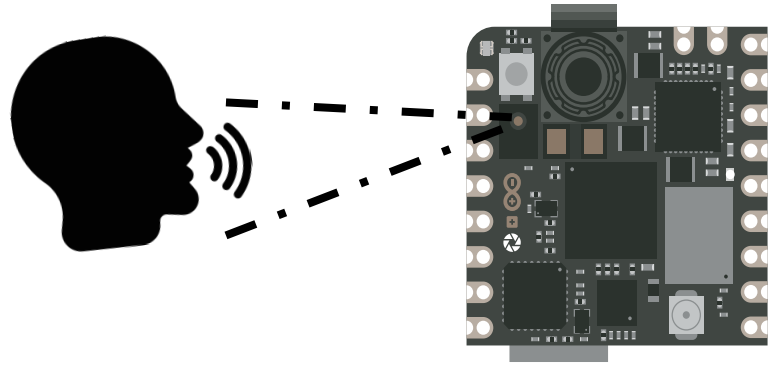
- Audio Recognition Module

- Simulation model

- Launch files

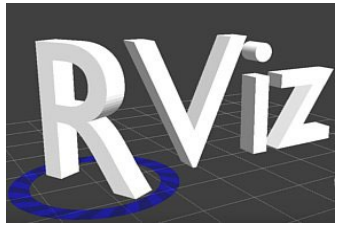
Audio Recognition Module

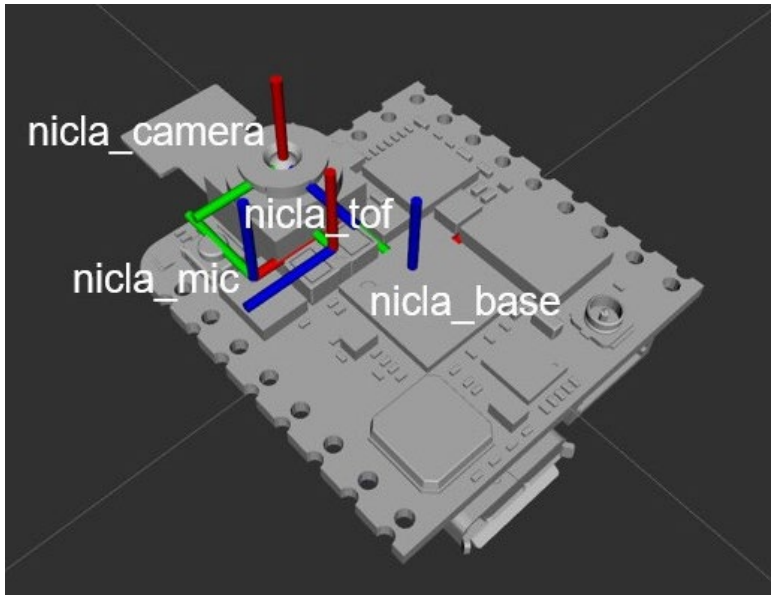


- This package also employs a speech recognizer module which elaborates the audio data in the receiver node
- Vocal commands are now possible with the Nicla
  - They are streamed in a dedicated ROS topic
- Based on VOSK library, by Alphacephei
- A grammar of words to be recognized can also be specified
- The audio can optionally be recorded in user defined audio chunks (seconds)

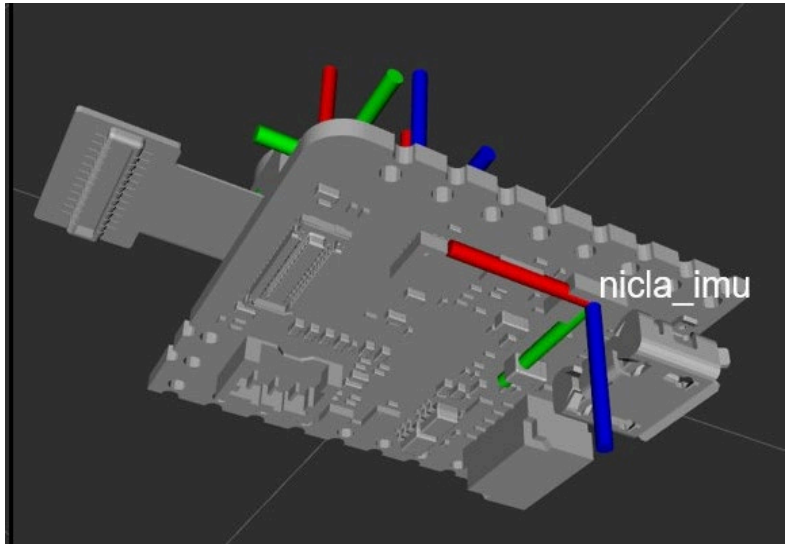
https://alphacephei.com/vosk/

Simulation





- Models (***urdf***) with correct sensors locations
- Gazebo-**simulated sensors** (no microphone)
- ***Xacro*** macro ready to be integrated in other robot models



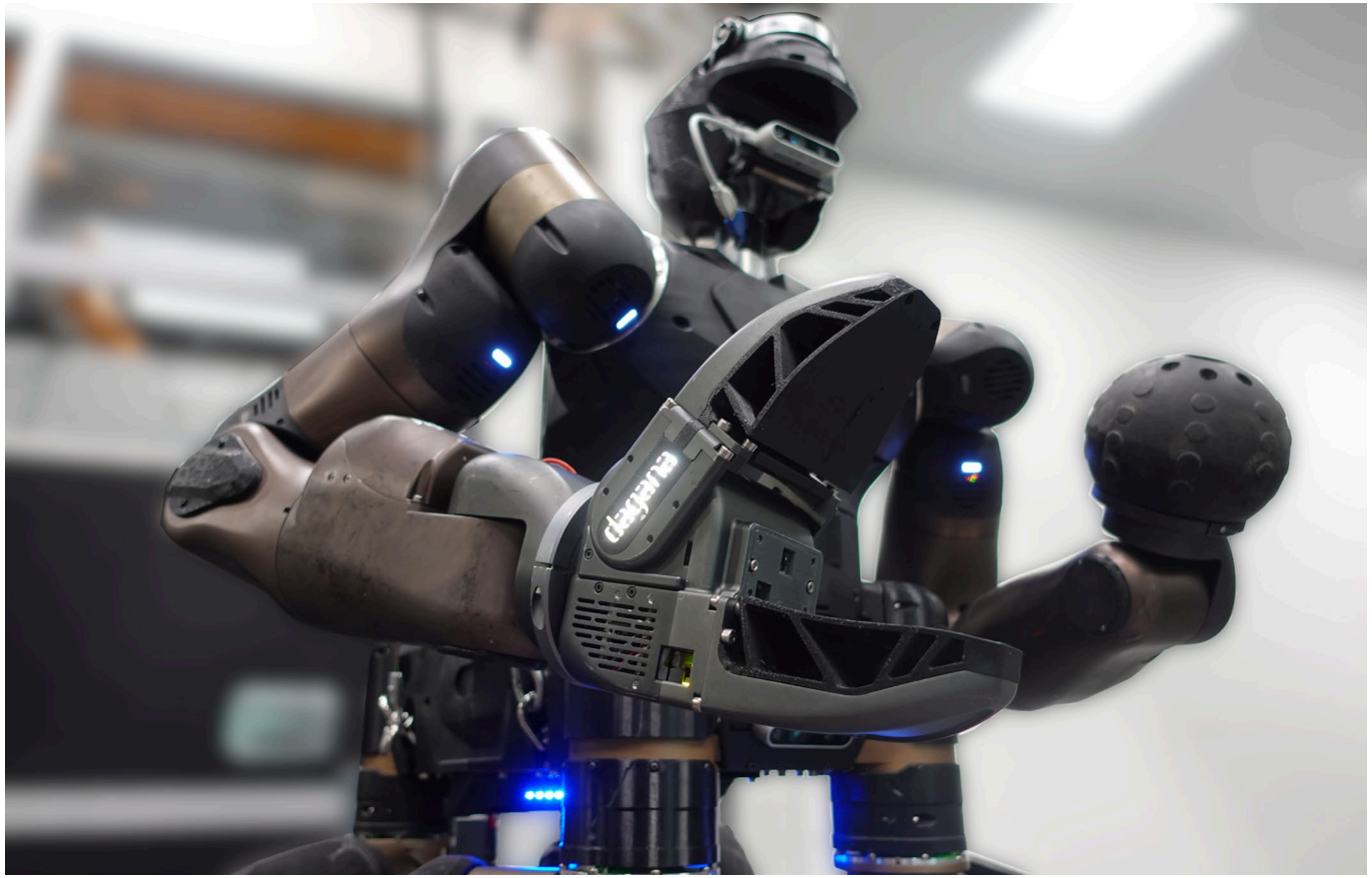
Launch files

- Ready-to-use driver and package with convenient config and launch files
- Just set Receiver IP and connection type (UDP/TCP) and you are ready to go

```
<?xml version="1.0" ?>
<launch>

    <arg name="nicla_name" default="nicla" />
    <arg name="receiver_ip"/>
    <arg name="receiver_port" default="8002" />
    <arg name="connection_type"/> <!-- tcp, udp -->
    <arg name="use_arduino" default="true"/> <!-- false for micropython use -->

    <arg name="enable_range" default="true" />

    <arg name="enable_camera_raw" default="false" />
    <arg name="enable_camera_compressed" default="true" />

    <arg name="enable_audio" default="true" />
    <arg name="enable_audio_stamped" default="false" />
    <arg name="enable_audio_recognition_vosk" default="false" description="Enable speech recognition with VOSK (need to be installed)"/>
    <arg name="audio_recognition_model_path" default=""/>
    <arg name="audio_recognition_listen_seconds" default="2.0" description="The speech recognition will process audio blocks of this duration"/>
    <arg name="audio_recognition_grammar" default="['']"
        description="VOSK format for grammar, [''] to use default model graph
            or as JSON array of strings like: ['open', 'bottle', 'cup', '[unk]'] take care of using single apex for the strings" />
    <arg name="audio_recognition_wave_output_filename" default=""
        description="store detected audio in subsequent files. Absolute path may be included.
            Mostly for debug purposes, leave empty for not storing"/>

    <arg name="enable_imu" default="true" />
```

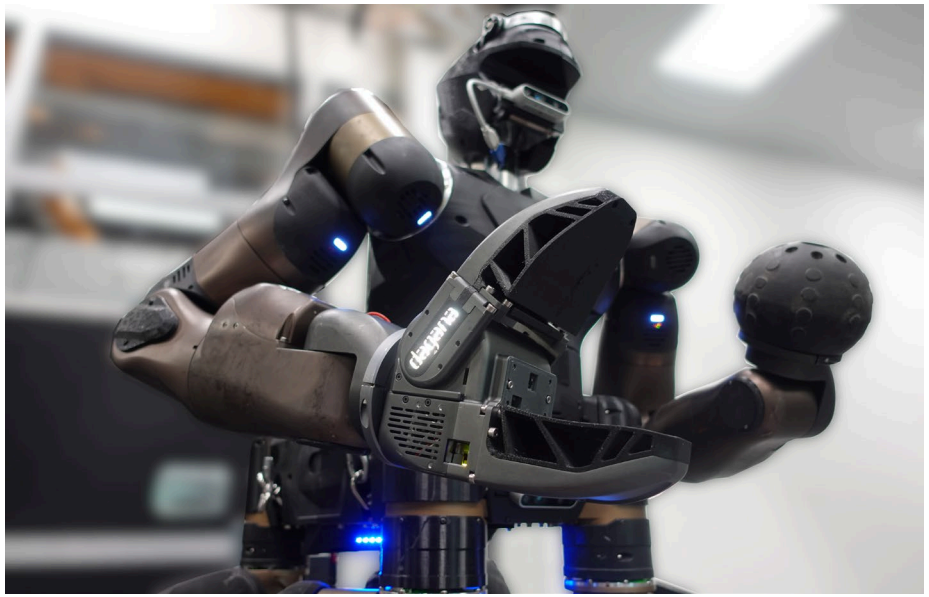
- Optional parameters for the driver version (Arduino/MicroPython), to enable/disable the sensors and the *VOSK*-based audio recognition
- Detailed instructions in the repos

Applications

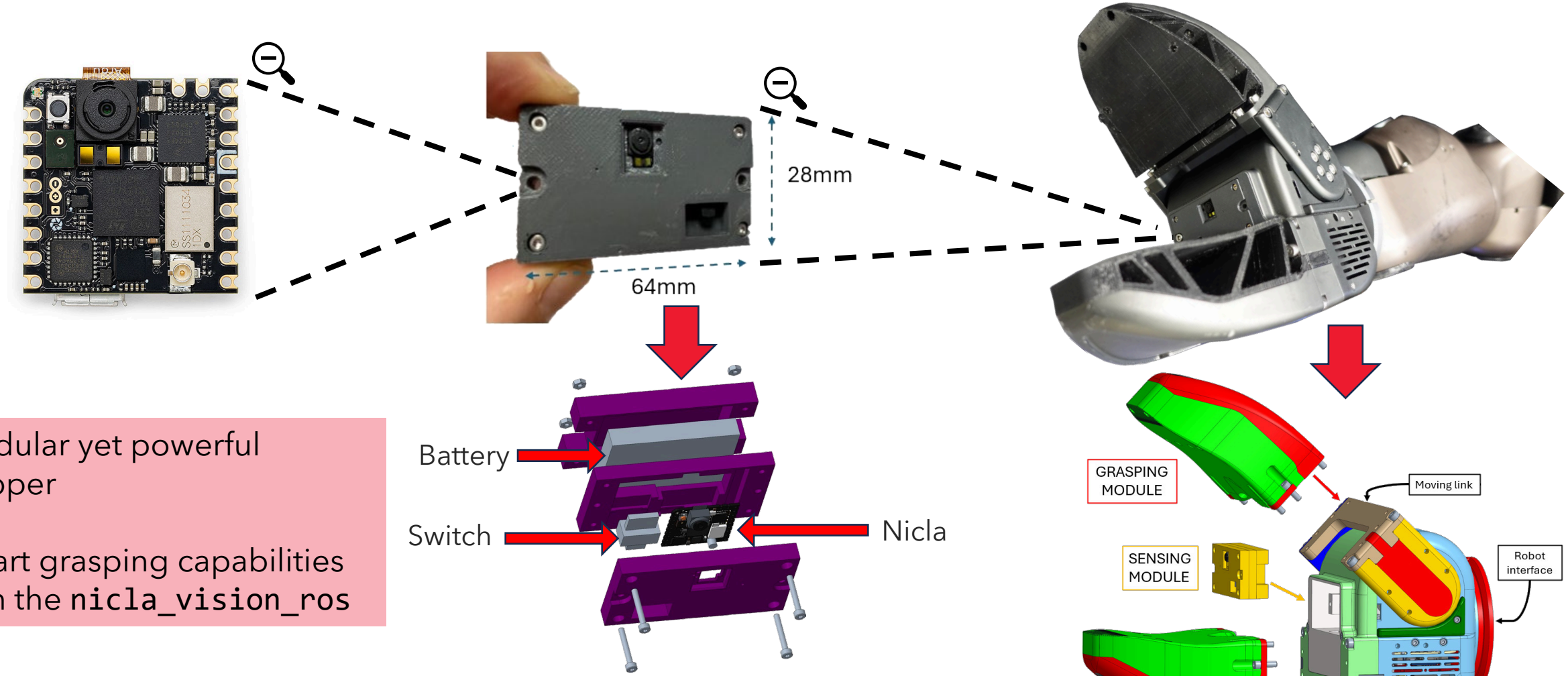


Applications

- Nicla Vision ROS package can make robotic hardware smarter !
- Easy integration thanks our ROS package, Nicla compact size, and wireless communication.
- Example: an **eye-and-ear-in-hand** end-effector leveraging these sensors. Fully in-hand multi-modal sensing for manipulation



A Sensing Module for the DAGANA End-Effector[1]

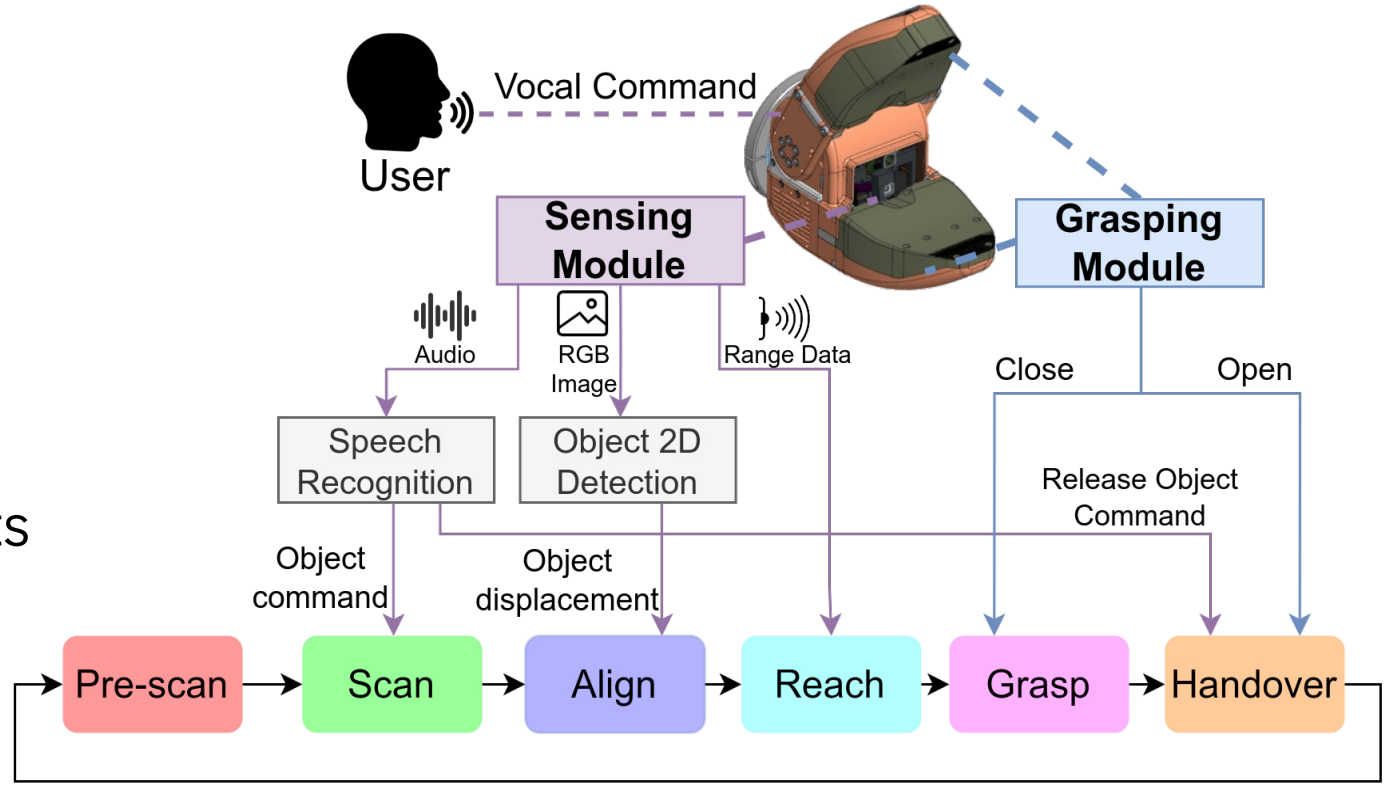


- Modular yet powerful gripper
- Smart grasping capabilities with the `nicla_vision_ros`

[1] E. Del Bianco, D. Torielli, F. Rollo, D. Gasperini, A. Laurenzi, L. Baccelliere, L. Muratore, M. Roveri, and Nikos G. Tsagarakis, "A High-Force Gripper with Embedded Multimodal Sensing for Powerful and Perception Driven Grasping", *IEEE-RAS International Conference on Humanoid Robots (Humanoids)*, 2024, *to be published*

Automatic Grasping Pipeline[1]

- Automatic search and grasp of selected object, utilizing only the end-effector sensing capabilities
- Nicla microphone for user vocal commands
- Nicla camera for detecting objects
- Nicla ToF for computing object distance



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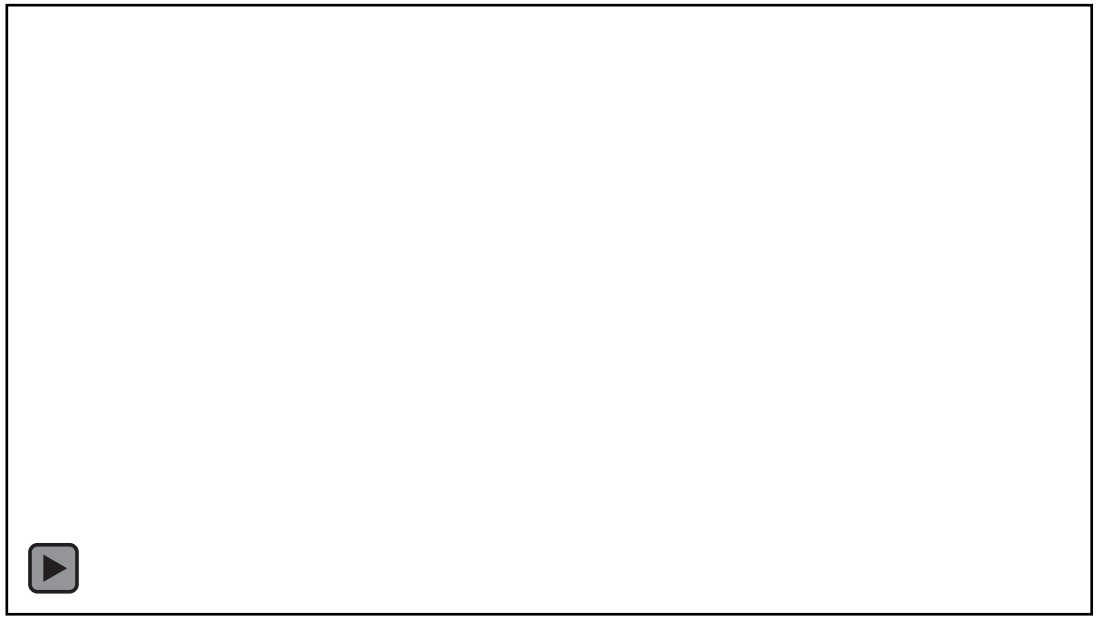
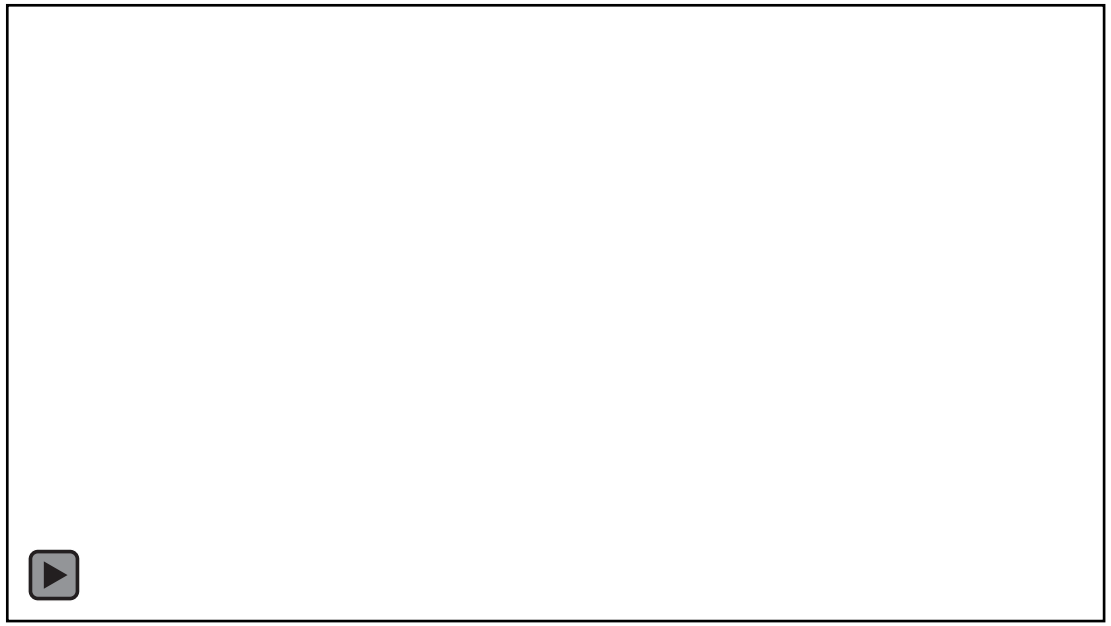
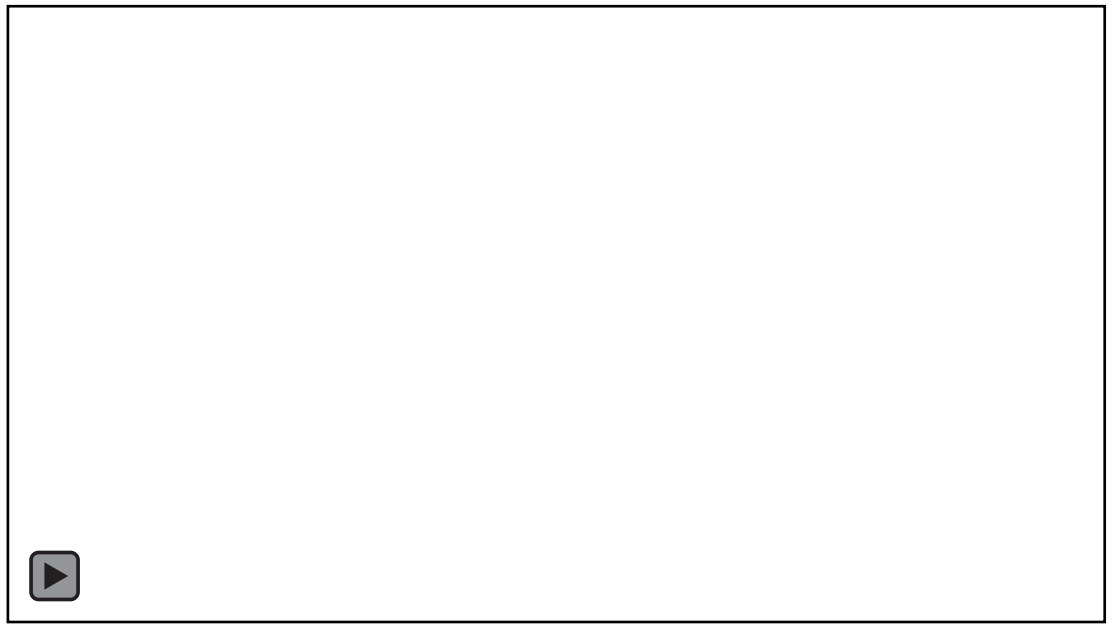
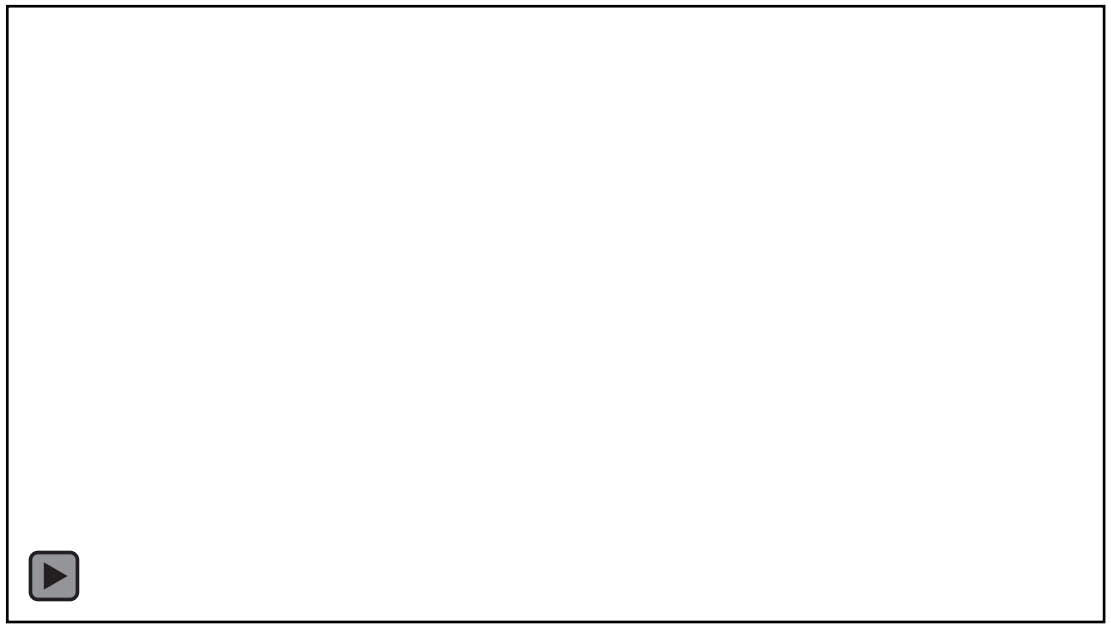
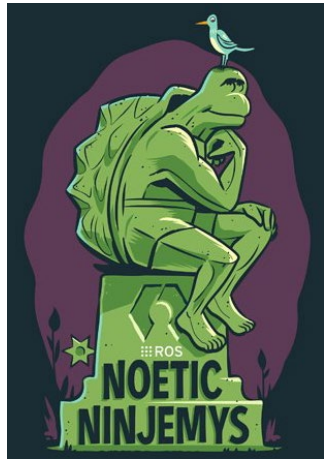








ROS Distributions



ROS

ROS 2

Binary from ROS repositories
(`noetic, humble, jazzy`)

GitHub

Open-source code publicy available with *Apache-2.0 License*

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