**Robot NICO for beginners**

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# About the robot

NICO - Neuro-Inspired COmpanion, is a humanoid developmental robot developed by the Knowledge Technology group at the University of Hamburg. Designed to facilitate research in neuro-cognitive modelling and multimodal human-robot interaction, NICO serves as an open-source platform that bridges the gap between advanced sensing capabilities and flexible, modular design.

A robot with a face and eyes

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Fig. 1 Robot NICO

**Key Features of NICO:**

* **Anthropomorphic Design:** NICO possesses a child-like anatomy with roughly 30 degrees of freedom (DoF), including movements in the head, arms, and hands. This design supports natural and intuitive human-robot interactions, making it suitable for studies in developmental robotics and social communication.
* **Advanced Sensorimotor Capabilities:** Equipped with high-resolution cameras in its eyes, stereo microphones in its ears, and simple tactile sensors in its palms, NICO can perceive its environment in a manner akin to human sensory processing. These features enable it to engage in tasks such as object recognition, sound localization, and rudimentary haptic exploration.
* **Expressive Facial Features:** NICO's face includes LED matrices that allow it to display a range of facial expressions, enhancing its ability to communicate emotions and engage in social interactions with human partners.
* **Open-Source and Modular Architecture:** Both the hardware and software of NICO are designed to be modular and open-source, encouraging researchers and developers to customize and extend its functionalities to suit various experimental needs.

## Applications in Research and Education

NICO has been utilized in various studies focusing on human-robot interaction, embodied cognition, and developmental learning. Its human-like sensorimotor capabilities make it an ideal platform for exploring how robots can learn from and adapt to their environments through interaction, similar to human developmental processes. NICO offers a tangible and interactive means to study concepts in robotics, artificial intelligence, neuroscience, and psychology.

For general overview of NICO's development and capabilities, you can watch the following video: <https://www.youtube.com/watch?v=n5ej9wjcZ7U>

## NICO robot construction

NICO’s hardware construction integrates various components to emulate human sensory and motor functions.

**Mechanical Structure**

* **Torso and Degrees of Freedom (DoF):** NICO's torso comprises 10 DoF, distributed between the head and arms. The head possesses 2 DoF, enabling yaw and pitch movements, while each shoulder has 3 DoF, mimicking the human shoulder's ball-and-socket joint, and an additional DoF at each elbow allows for bending motions.
* **Hands:** The robot's hands are equipped with 22 additional DoF, achieved through an underactuated design utilizing 8 motors. Motors control fingers via draw-bars. The third and the fourh finger on each palm are coupled. This configuration allows for intricate manipulation tasks, closely resembling human hand movements.

A close up of a device

AI-generated content may be incorrect.A close-up of a device

AI-generated content may be incorrect.A robot hand with text and symbols

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Fig. 2 Robot NICO RH6D hand

**Actuation**

In arms NICO employs Robotis Dynamixel servomotors for its joints and movements. Most of the servomotors are DYNAMIXEL MX-64AR is a high-performance smart actuator developed by ROBOTIS. These servomotors can be monitored and manually controlled by Dynamixel Wizard software (more info in the Installation manual).

**Key Features of servomotors:**

* **Integrated Design:** Combines a DC motor, reduction gearhead, controller, driver, and network interface into a single module.
* **High-Resolution Position Sensing:** Equipped with a 12-bit contactless absolute encoder, providing 4,096 positions within 360 degrees, fine angular movements accurate to 0.088 degrees.
* **Control Algorithms:** Utilizes PID controller to correct positioning errors.
* **Communication Interface:** Supports RS-485 asynchronous serial communication with a baud rate ranging from 8,000 bps to 4.5 Mbps data transmission.

**Specifications:**

* **Microcontroller:** 32-bit ST Cortex-M3 running at 72 MHz.
* **Gear Ratio:** 200:1, providing a balance between speed and torque.
* **Stall Torque:** 6.0 N·m at 12V with a stall current of 4.1 A.
* **No-Load Speed:** 63.0 RPM at 12V.
* **Operating Voltage:** Recommended at 12.0V, with an acceptable range from 10.0V to 14.8V.
* **Dimensions:** 40.2 mm (W) x 61.1 mm (H) x 41 mm (D). citeturn0search3
* **Weight:** 165 grams. citeturn0search3

**Construction:**

* **Aluminum Front Case**
* **Full Metal Gears:** Incorporates metal gears in the front and middle stages, plastic back case.

**Unified control for arms and hands:**

Dynamixel servomotors in NICO’s arms and neck (mostly Dynamixel MX64AR) contain intelligent controller, communicate over RS485 interface and to USB hub are connected via Dynamixel LN101 USB downloader.

A usb flash drive with a cable

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Fig. 3 LN101 converter

You can see it connected into USB hub behind the robot. This USB hub has to be connected to your computer. Other robot subsystems are connected to this hub as well.

A black device with wires

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Fig. 4 NICO USB hub

Robot hands contain small and simple servomotors without intelligent controllers. Hands contain converter which provides just small subset of Dynamixel servomotors functionality and therefore you cannot see servomotors in robot’s hands in the list of Dynamixel motors provided by Dynamixel Wizard.

**Vision system:**

* **Vision:** The robot is equipped with two high-resolution 4K cameras located in the eye sockets.
* **Frame Rate:** The cameras can operate at up to 60 frames per second (fps) at 4K resolution, ensuring smooth video capture suitable for real-time processing and analysis.
* **Field of View:** The cameras are positioned with overlapping fields of view, enabling stereoscopic vision. This arrangement allows NICO to perceive depth and spatial relationships, enhancing its ability to interact with its environment effectively.
* These camera specifications enable NICO to process high-quality visual information, supporting complex tasks such as object recognition, tracking, and interaction within dynamic environments.

A person sitting at a desk in a room

AI-generated content may be incorrect.A fish eye view of a room

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Fig.3 Left and right camera view

**Auditory:** Stereo sound capture is achieved through two microphones mounted on realistic 3D-printed pinnae (outer ears). This arrangement enhances the robot's ability to localize sound sources and process auditory information effectively.

**Speaker:** NICO is equipped with one speaker enabling amplification of voice and speech generated by connected computer.

**Facial Expression**

NICO features LED arrays in the eyebrow and mouth regions, enabling the display of various facial expressions such as happiness, anger, and surprise. This capability enhances human-robot interaction by allowing the robot to convey emotional states visually.

**Robotic Hand RH6D**

The RH6D is a child-sized dexterous robotic hand developed by Seed Robotics. It is designed to provide advanced grasping and sensing capabilities for exploration and learning scenarios. The hand is compatible with NICO and can be integrated to enhance its manipulation abilities, contributing to its humanoid appearance and functionality in social research contexts.

**Configuration of NICO robot in FMFI UK – FT Lab**

A robot on a table

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Fig. 4 Robot NICO in FT Lab – with touchscreen

In FT Lab, robot desk contains touchscreen display, which can be connected to your computer by HDMI interface. Robot’s index fingers are adapted so that touchscreen recognizes touch by NICO‘s index finger.

**References**

**Citation for publications**

Original paper

[Matthias Kerzel, Erik Strahl, Sven Magg, Nicolás Navarro-Guerrero, Stefan Heinrich, Stefan Wermter. NICO – Neuro-Inspired COmpanion: A Developmental Humanoid Robot Platform for Multimodal Interaction. *Proceedings of the IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN). pages 113 - 120. Lisbon, Portugal.*2017.](https://www2.informatik.uni-hamburg.de/wtm/publications/2017/KSMNHW17/index.php)

General info about the robot

<https://www.seedrobotics.com/nico-robot>

Original robot design (not maintained)

<https://github.com/knowledgetechnologyuhh/NICO-cad>

<https://www.inf.uni-hamburg.de/en/inst/ab/wtm/research/neurobotics/nico>

Controlling NICO – student’s project

<https://dai.fmph.uniba.sk/projects/nico/index.php?title=A_student_project_on_controlling_Nico%27s_hand_using_Arduino_and_analog_sensors>

Teaching NICO how to grasp

<https://www.frontiersin.org/journals/neurorobotics/articles/10.3389/fnbot.2020.00028/full>

NICO Dynamixel motors

<https://emanual.robotis.com/docs/en/dxl/mx/>

General overview of Dynamixel motors

<https://www.dynamixel.com/whatisdxl.php>

Dynamixel Wizard for simple manipulation with robots servomotors

<https://emanual.robotis.com/docs/en/software/dynamixel/dynamixel_wizard2/>

Dynamixel MX64 AR motor manual (look for AR type – means RS485 interface)

<https://emanual.robotis.com/docs/en/dxl/mx/mx-64/>