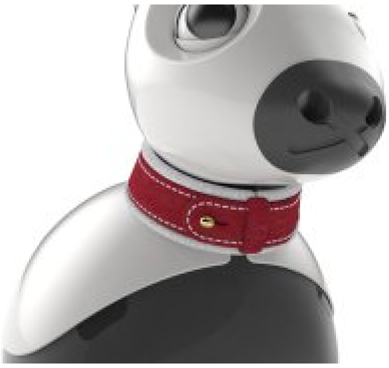

Specification

Outline

Platform

MiRo is based on a differential drive platform with a 3-degrees-of-freedom jointed neck. Weighing in at around 3kg, and sized similarly to a small mammal such as a cat or a rabbit, MiRo will typically run for several hours before needing recharging.

Sensors

Stereo cameras in the eyes and stereo microphones in the ears are complemented by two additional microphones (one inside the head and one in the tail) and by a sonar ranger in the nose. In the body, four light level sensors and two 'cliff sensors' are arrayed around the skirt, and many capacitive sensors are distributed across the inside of the body shell and upper head shell to sense direct human contact. Interoceptive sensors include twin accelerometers and battery state sensing.

Actuators

Apart from the wheels and the neck, additional servos drive rotation of each ear, tail droop and wag, and closure of each eyelid. The wheel and neck movements are equipped with feedback sensors (potentiometers for neck joint positions and optical shaft encoders for wheel speed). An on-board speaker is also available to generate sound output.

Processing

MiRo is based around a Raspberry Pi 3B+ running a standard Raspbian distribution.

POWERED BY Raspberry Pi

Simulation

The MiRo simulator runs on the popular Gazebo robot simulator.

Platform

Physical

Mass	3.3 kg (2.9 kg without battery pack)
Wheel track	164 mm
Wheel diameter	90 mm
Maximum forward speed	400 mm/sec

Power

Main battery	NiMH 4.8V 10Ah
Main battery life	Varies with usage: representative 6+ hours active, 12+ hours standby.

Sensors

Exteroceptive

Microphones[1]	4×	16-bit @ 20kHz
Cameras[2]	2×	1280×720 @ 15fps 640×360 @ 25fps 320×240 @ 35fps
Proximity[3]	1×	Sonar in nose (3cm up to 1m)
Touch	28×	14× in body, 14× in head; capacitive
Light	4×	Spread around body skirt
Cliff[4]	2×	Front edge of body skirt

Interoceptive

Motion	2×	1× opto sensor in each wheel (also back EMF)
Position	3×	1× position sensor in each body joint

Accelerometer	2×	1× in body, 1× in head
Voltage	1×	Battery voltage

[1] Two primary microphones in the base of the ears are supplemented by a noise-rejection microphone inside the head and an additional external microphone in the tail.

[2] Other frame sizes and aspect ratios are available; frame rate can be adjusted freely between 1.0 fps and the listed maximum.

[3] Sonar reflections are more reliable at shorter ranges—sensor will report good reflectors at up to 1 metre.

[4] Cliff sensors can be fooled by varying lighting conditions and/or presence of unrelated objects and by backwards motion; users should not assume they will be sufficient to prevent the robot driving off edges.

Actuators

Kinematic

Main wheels	2×	Differential drive
Body joints	3×	Lift, yaw, and pitch

Cosmetic

Tail (wag/droop)	2×	Wagging (side-to-side) and droop (up-and-down) motions
Ears (rotate)	2×	Left and right ear rotate independently
Eyelids (open/close)	2×	Two eyelids open and close independently

Supplementary

Illumination	6×	RGB illumination LEDs shine through the body shell, three on each flank
Sound output	1×	Streaming audio digitised at 8kHz

Processing

Embedded Stack

P1	3× STM32F030	ARM Cortex M0 @ 24MHz 8kB SRAM 64kB FLASH ROM
P2	1× STM32H743	ARM Cortex M7 @ 400MHz 1MB SRAM 2MB FLASH ROM

On-board Computer

P3	1× Raspberry Pi 3B+	ARM Cortex A53 Quad Core @ 1.4GHz 1GB LPDDR2 RAM 16GB uSD FLASH ROM Bluetooth, WiFi, USB expansion ports

The factory-supplied SD card (or disk image) carries a standard Linux distribution (Raspbian) with a minimal set of tools (including ROS) and the MDK installed. Users are free to install their own software, as required, for example by using the Raspbian package manager.

Simulation

The simulation[5] of MiRo runs in the Gazebo robot simulator.

[5] Owing to limitations of simulation, the simulated robot lacks some of the faculties of the physical robot: at time of writing, touch and audio sensors, audio output, and illumination output are not implemented.

Developed in partnership with The University Of Sheffield.
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