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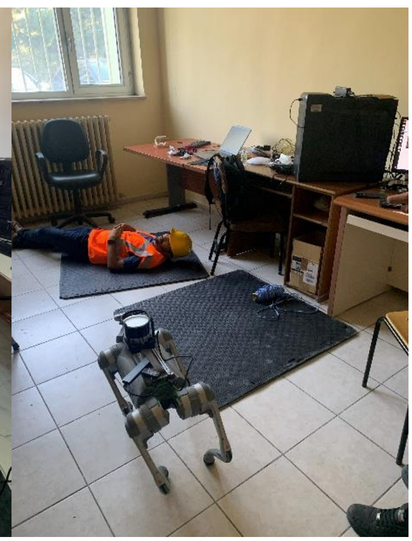
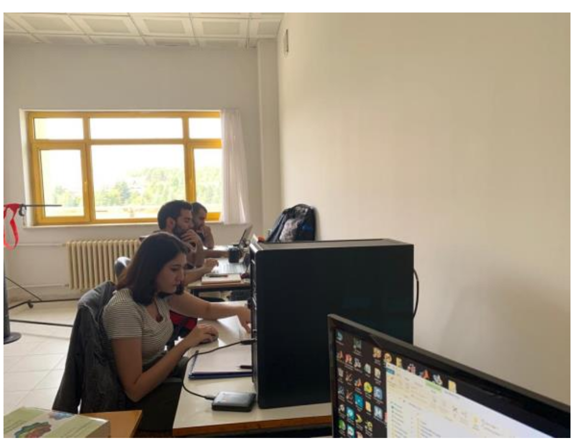
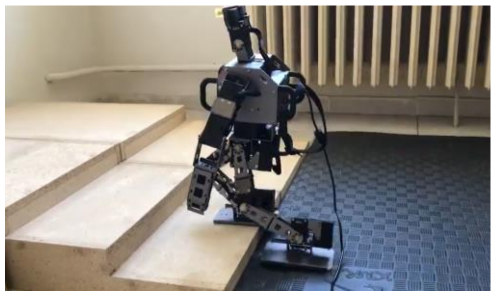
Robotics and Artificial Intelligence Laboratory (RAI)



1- ROBOTIS OP3 HUMANOID ROBOT – Technical Specifications

General Information:

ROBOTIS OP3 is an advanced mini humanoid robot measuring 510 mm in height, weighing 3.5 kg, and featuring 20 degrees of freedom (DOF). Its new-generation XM430-W350-R actuators provide high torque and more precise control. The robot's main processor is based on an Intel NUC i3; with 8 GB DDR4 RAM and a 250 GB M.2 SSD, it offers a major performance improvement over the previous generation.

Sensors and Hardware:

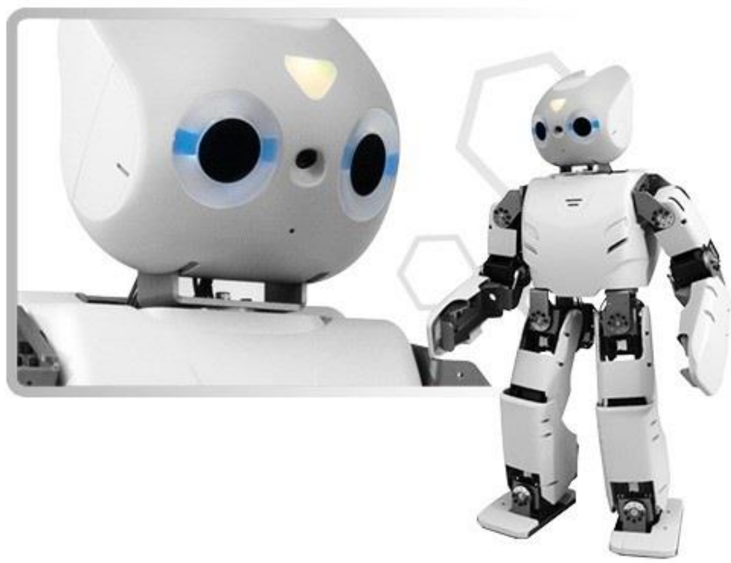
OP3 is equipped with a Logitech C920 HD camera and an IMU comprising a three-axis gyroscope, accelerometer, and magnetometer. It also includes one RGB LED, three status LEDs, four buttons, and a speaker. The modern, open-source OpenCR platform is used as the sub-controller.

Connectivity and Power:

It supports Ethernet, Wi-Fi 802.11ax, Bluetooth 5, USB 3.0, HDMI, and DisplayPort. It is powered by an 11.1 V 3300 mAh Li-Po battery.

Software and Development:

It operates most efficiently on 64-bit Linux and supports C++, ROS 2, and the DYNAMIXEL SDK. Its advanced computing power, high-resolution camera, and ROS 2 compatibility make it a powerful platform for research, education, artificial intelligence, and RoboCup projects.

2- ROBOTIS OP2 HUMANOID ROBOT – Technical Specifications

General Information:

ROBOTIS OP2 is a previous-generation humanoid robot measuring 450 mm in height, weighing approximately 3 kg, and featuring 20 degrees of freedom. It uses MX-28 servo motors as actuators and has an older servo architecture than OP3.

Sensors and Hardware:

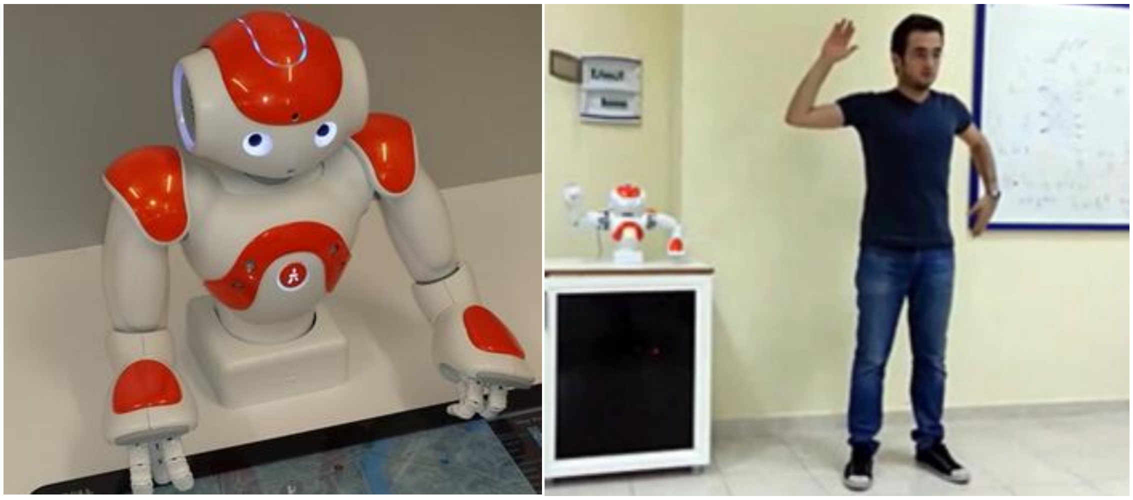
Its main processor is a dual-core Intel Atom N2600; it includes 2 GB DDR3 RAM and a 32 GB mSATA SSD. A Logitech C905 camera serves as its imaging unit. The IMU contains a three-axis accelerometer and gyroscope. A CM-730 serves as the sub-controller.

Connectivity and Power:

It supports Ethernet, 2.4 GHz Wi-Fi (802.11n), USB 2.0, and mini HDMI connections. It uses an 11.1 V 1800 mAh Li-Po battery. Its communications, processing power, and camera quality are more limited than those of OP3.

Software and Development:

It is compatible with 32-bit Linux and 32-bit Windows. Development can be performed using C++, ROS (ROS 1), and OpenCV. It has been used in education, image processing, and RoboCup research, but its hardware falls behind OP3's current standards.



3- Aldebaran / SoftBank NAO TORSO HUMANOID ROBOT – Technical Specifications

General Information:

NAO is a professional humanoid robot measuring 58 cm in height, weighing approximately 5–5.5 kg, and featuring a total of 25 degrees of freedom (DOF). It is a compact humanoid platform widely used in education, research, artificial intelligence, social robotics, and laboratory studies. Its soft outer covering and safe servo architecture enable safe use in both educational and research environments.

Sensors and Hardware:

NAO's central processor is Intel Atom-based (Z530 or E3845, depending on the model). It includes 2–4 GB RAM and 16–32 GB of internal eMMC storage. It has dual cameras (an upper HD camera and a lower VGA camera), four microphones, stereo speakers, and a comprehensive IMU sensor package comprising a three-axis accelerometer, gyroscope, and magnetometer. Balance sensors and tactile sensors are also located in the soles of its feet.

Connectivity and Power:

Wi-Fi (802.11 a/b/g/n), Ethernet, USB, and, on some models, mini HDMI ports are available. It is powered by a 21.6 V Li-ion battery and provides an average operating time of 1.5–2.5 hours.

Actuation and Motion:

NAO is equipped with specially designed Aldebaran Smart Actuator servo motors. With 25 DOF distributed across the head, arms, legs, and hands, it can perform complex movements such as walking, sitting down and standing up, balancing, dancing, gesturing, and facial expressions.

Software and Development:

NAO runs the Linux-based NAOqi OS. It can be programmed through numerous platforms, including Python, C++, Java, ROS, and Choregraphe. OpenCV is supported for image processing. It offers extensive API support for human–robot interaction, speech recognition, behaviour programming, and educational research.

4. Unitree Go2 – Technical Specifications

General Information:

Unitree Go2 is an advanced quadruped robotic-dog platform distinguished by its high mobility and durability. It is designed for autonomous navigation, research, industrial applications, and education. It can carry approximately 40–45 kg and is frequently preferred in modern robotics research because of its high speed, advanced sensors, and AI-assisted mobility capabilities.

Sensors and Hardware:

Go2 is equipped with a broad sensor suite for environmental perception, including 3D LiDAR (LiDAR L1 / 4D LiDAR option), depth sensors, an IMU, and ultrasonic sensors. It has four high-torque leg actuators; the motors are optimised for torque control and dynamic balance. Its AI processor and onboard computer enable real-time motion planning and autonomous navigation.

Connectivity and Power:

Go2 supports Wi-Fi, Bluetooth, and 4G/5G communications (depending on the model). Its high-capacity Li-ion battery provides an operating time of approximately 1.5–2.5 hours. The robot is also compatible with a wireless charging adapter and an independent charging station.

Motion and Performance:

Unitree Go2 offers advanced motion capabilities such as stable walking over varied terrain, jumping, running, obstacle negotiation, and rapid changes of direction. Its maximum speed is approximately 5 m/s. It delivers high performance through its new-generation battery management system (BMS), advanced balance algorithms, and torque-based control system.

Software and Development:

Go2 can be programmed using ROS/ROS 2, Python, C++, and Unitree's own SDK. It provides developers with extensive API support for mapping, autonomous navigation, SLAM, computer vision, and deep learning applications. Its mobile application and control units enable rapid switching between manual and autonomous modes.

5. DJI Matrice 350 RTK – Technical Specifications

General Information:

DJI Matrice 350 RTK is an advanced industrial drone platform designed for industrial applications, mapping, search and rescue, infrastructure inspection, and professional aerial missions. With its advanced flight safety, long range, high payload capacity, and RTK precision positioning features, it is regarded as a standard platform for professional fieldwork.

Sensors and Hardware:

M350 RTK is equipped with a three-channel RTK GNSS module, vision sensors, infrared obstacle sensing, an altimeter, an IMU, and omnidirectional sensing systems. It therefore provides high stability and centimetre-level positioning accuracy in complex terrain. Its payload capacity is approximately 2.7 kg, and it is compatible with professional camera and LiDAR payloads such as the Zenmuse H20, H20T, P1, and L1.

Connectivity and Power:

DJI O3 Enterprise provides a transmission range of up to 20 km. The dual TB65 battery system enables a maximum flight time of 55 minutes. The batteries can be rapidly replaced and feature intelligent heating and cooling. USB-C, CAN ports, and modular connectivity options are supported.

Flight Performance:

M350 RTK provides high endurance in professional missions, with a service ceiling of 7,000 metres, wind resistance of 15 m/s, and multiple flight modes. It features a low-light-assisted sensor system for night missions. Its triple GNSS antenna configuration and dual IMU system enhance flight safety.

Software and Development:

Advanced flight missions, including mapping, 3D modelling, and route planning, can be managed through the DJI Pilot 2 application. DJI SDK, Payload SDK, and Cloud API support are available for software development. It is used effectively in industrial data collection, autonomous missions, RTK-based mapping, and inspection projects.

6. TurtleBot2 – Technical Specifications

General Information:

TurtleBot2 is an open-source mobile robot platform designed for education, research, mobile robotics, SLAM, and autonomous navigation studies. It is fully compatible with ROS (Robot Operating System) and is used as a standard educational robot in university laboratories worldwide. Its body is lightweight, modular, and readily extensible.

Sensors and Hardware:

TurtleBot2's primary sensor is a Kinect v1 / Asus Xtion Pro depth sensor (depending on the model). This sensor provides high performance in 3D mapping, object detection, and SLAM applications. The robot is equipped with a gyroscope, wheel encoders, collision sensors, and battery-status monitoring sensors. Its two-wheel differential-drive configuration enables agile and stable movement.

Connectivity and Power:

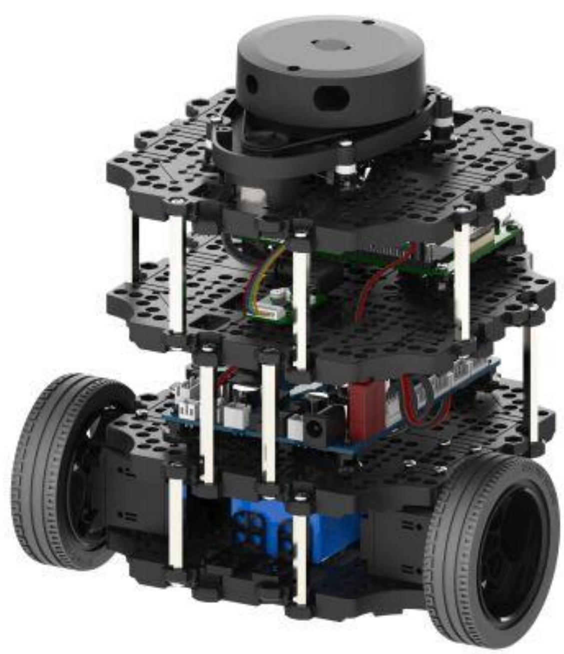
The robot's main control computer is generally configured as a laptop or NUC mini PC. Connectivity is provided via USB, Wi-Fi, and Ethernet, depending on the computer used. TurtleBot2 uses a high-capacity 12 V 22 Ah LiFePO4 battery and provides an operating time of approximately 2–3 hours on a single charge.

Motion and Performance:

TurtleBot2 provides reliable and stable mobile operation with its Yujin iClebo Kobuki-based chassis. Its differential-drive system offers high accuracy in forward and reverse motion, turning, manoeuvring in confined spaces, autonomous mapping, and navigation tasks. Wheel encoders improve the precision of motion control.

Software and Development:

The robot fully supports ROS (ROS 1) and has an extensive ecosystem of open-source packages. It is an ideal platform for SLAM (Gmapping, Cartographer), autonomous navigation, mapping, computer vision, and robotics applications. It can be readily programmed in Python and C++, and sensors and accessories can be integrated rapidly.



7. TurtleBot3 Burger (Raspberry Pi 4 – 2 GB) – Technical Specifications

General Information:

TurtleBot3 Burger is an ultra-compact mobile robot platform designed for education, research, ROS/ROS 2 applications, SLAM, and autonomous navigation studies. Its open-source, lightweight, economical, and modular design has made it a widely used standard entry-level research robot in laboratories. Its compact 138 mm body and lightweight chassis provide excellent manoeuvrability in confined spaces.

Sensors and Hardware:

The robot's primary sensor is a 360° 2D LiDAR (HLS-LFCD-LDS), which provides high distance-measurement accuracy. It also includes an IMU (three-axis accelerometer and three-axis gyroscope), wheel encoders, and collision sensors. A Raspberry Pi 4 (2 GB RAM) is used as the main computer, allowing ROS 1 and ROS 2 packages to run smoothly.

Connectivity and Power:

It can be remotely controlled via the Raspberry Pi's Wi-Fi connection. USB ports enable a camera or additional sensors to be connected. TurtleBot3 Burger uses an 11.1 V Li-Po battery and provides approximately 1.5–2.5 hours of operation, depending on the application. Its rechargeable, easily replaceable battery module facilitates rapid field use.

Motion and Performance:

Its differential-drive system provides high accuracy in forward and reverse motion, turning, and precise autonomous navigation. Wheel encoders improve odometry accuracy. Its low weight makes collision, incline, and speed control safer. The open-source servo controller (OpenCR) provides stable motor control.

Software and Development:

TurtleBot3 is fully compatible with ROS 1 and ROS 2. It works with mapping packages such as Gmapping, Hector SLAM, and Cartographer, as well as autonomous driving software such as Navigation Stack or Nav2. It can be readily programmed using Python and C++. Its open-source mechanics, electronic schematics, and 3D-printing files allow users to develop, expand, and modify the platform.

8. OpenZeka Mini Autonomous Vehicle Kit – Technical Specifications

General Information:

The OpenZeka Mini Autonomous Vehicle Kit is a 1/10-scale mobile robotic vehicle platform designed for autonomous driving, deep learning, computer vision, mapping, and navigation research. It offers a standard solution for autonomous vehicle development training at universities and R&D laboratories. Its robust vehicle chassis, powerful AI processor, and multisensor perception architecture make it ideal for modelling real-vehicle behaviour at a small scale.

Sensors and Hardware:

The vehicle provides 3D imaging and depth perception through a ZED stereo camera, as well as environmental scanning, obstacle detection, and SLAM support through a 360° LiDAR. Position, balance, and motion are also measured precisely using an IMU (accelerometer, gyroscope, and magnetometer) and wheel encoders. NVIDIA Jetson-series devices available in the laboratory (TX1, TX2, and AGX Orin) are used as the computing units; these processors deliver the high performance required to run real-time artificial intelligence, image-processing, and autonomous-driving algorithms.

Connectivity and Power:

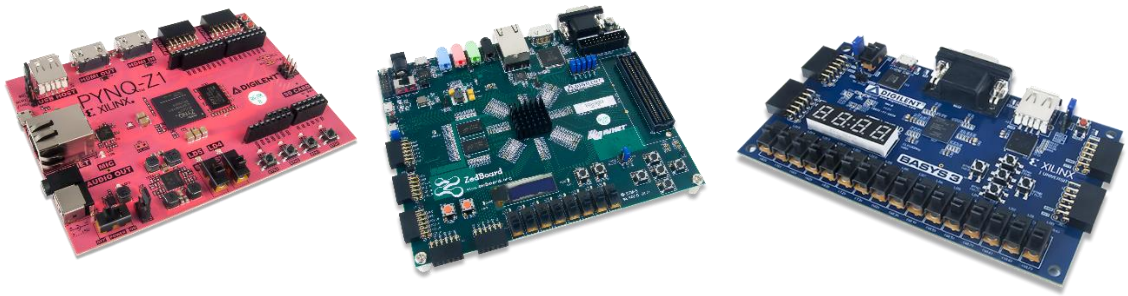
The vehicle can be remotely operated via Wi-Fi; a seven-port USB 3.0 hub enables the connection of cameras, LiDAR, and other peripheral devices. Its power system has a robust battery infrastructure capable of simultaneously powering the Jetson, sensors, and vehicle motors. The high-capacity battery provides long operating times and can be rapidly replaced.

Motion and Performance:

The mini vehicle platform supports behaviours such as forward and reverse driving, precise turns, realistic acceleration and deceleration, and stable motion on different surfaces. Its differential-drive-like control model is suitable for testing autonomous-driving algorithms. LiDAR and camera data enable highly accurate mapping, obstacle detection, lane following, and route planning.

Software and Development:

It is supplied with ready-to-use autonomous vehicle software: functions such as joystick-controlled driving, data recording, lane following, traffic-sign recognition, SLAM, and autonomous navigation are available at a basic level. Its ROS-based architecture allows users to add new algorithms in Python or C++. Deep learning models can run on the Jetson, and the open-source architecture makes the system readily extensible and customisable.



9. FPGA Boards – Technical Specifications

Our laboratory has PYNQ-Z1/Z2, ZedBoard, and Basys boards, as well as high-cost specialised Xilinx FPGAs, such as the Zynq UltraScale+ MPSoC, with high-performance computing and image-processing capabilities.

10. DJI Tello – Technical Specifications

General Information:

DJI Tello is a mini educational drone widely used in education, image processing, flight control, autonomous-flight algorithm development, and drone programming. Its lightweight design, flight-safety protections, and ease of programming make it an ideal platform for laboratories, schools, and robotics training centres. Tello provides a reliable entry-level experience for both manual flight and autonomous missions.

Sensors and Hardware:

Tello provides stable indoor flight using a downward-facing optical-flow sensor and an ultrasonic altitude sensor. Its onboard 5 MP camera streams 720p HD video and provides a suitable data source for applications such as image processing and target tracking. Its IMU (accelerometer and gyroscope) improves drone stability and flight control. Its lightweight yet robust body is suitable for intensive educational use.

Connectivity and Power:

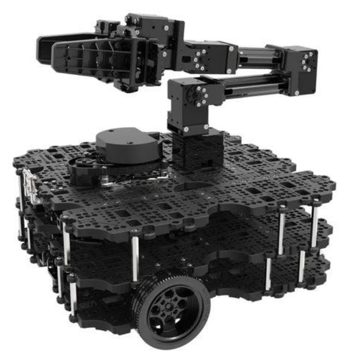
The drone connects via Wi-Fi to a smartphone, computer, or control application using the Tello SDK. Real-time video is transmitted over Wi-Fi. Tello uses a 3.8 V 1100 mAh Li-Po battery and typically provides a flight time of 12–13 minutes. Because the battery can be replaced easily, uninterrupted use can be maintained in educational environments.

Motion and Performance:

Tello supports automatic take-off and landing, hovering, rapid manoeuvres, and safe flight modes. While providing high stability indoors, it can be programmed with entry-level obstacle avoidance and simple autonomous behaviours. Its lightweight design provides high collision tolerance, and its low-energy propellers offer a safe educational experience.

Software and Development:

Tello can be readily programmed in Python using the Tello SDK. It is also used with Scratch, TelloBridge for ROS, OpenCV-based image-processing applications, and AI-based control projects. It has a wide range of uses in educational settings, including autonomous flight, object recognition, drone choreography, and AI-assisted motion control.



11- ROBOTIS OpenMANIPULATOR-X (RM-X52-TNM) – Technical Specifications

General Information:

OpenMANIPULATOR-X is a modular robotic-arm/manipulator platform developed with open-source hardware and software. It is suitable for education, research, mobile manipulation, pick-and-place operations, kinematic/dynamic control, ROS-based robotics projects, and automation studies. Its lightweight and compact structure allows it to be used in desktop systems or on mobile robot platforms such as TurtleBot3.

Sensors and Hardware / Actuators:

Actuators: DYNAMIXEL XM430-W350-T servo motors

Degrees of Freedom (DOF): 5 (4-DOF arm + 1-DOF gripper)

Maximum Payload: 500 g

Joint Speed: ~46 RPM

Dimensions and Mechanics:

Assembled Weight: ~0.70 kg

Reach: ~380 mm

Gripper Opening: ~20–75 mm

Electrical and Communications:

Input Voltage: 12 V DC

Communication Interface: TTL-Level Multidrop Bus (DYNAMIXEL Bus)

Control / Software / Development:

Controller: Can be used with a PC or the OpenCR embedded control board.

Software Compatibility: Supports ROS (and ROS-compatible software), DYNAMIXEL SDK, Arduino, Processing, etc.

Features: Open-source hardware and software, modular architecture, easy assembly, maintenance and expansion, and suitability for integration with mobile platforms.

Applications and Areas of Use:

Desktop manipulation and pick-and-place applications

Research and development of robotic control algorithms

Development of mobile manipulators (e.g. a robotic arm combined with a wheeled platform)

ROS-based education and laboratory studies

Prototyping, end-user automation, and grasping tasks

12- DJI Mavic 2 Pro – Technical Specifications

General Information:

DJI Mavic 2 Pro is a compact and portable quadcopter drone designed for professional and amateur applications such as aerial photography, video recording, mapping, and surveillance. Its foldable design, low weight, and powerful camera and sensor system make it suitable for travel, fieldwork, education, and research.

Sensors and Camera:

Camera Sensor: 1-inch CMOS, 20 effective megapixels

Lens: 28 mm equivalent (wide-angle), f/2.8–f/11 aperture range

Photo Resolution: 5472 × 3648 px

ISO Range: Photograph (100–3200 automatic / 100–12800 manual); video (100–6400)

Shutter Speed: 8–1/8000 s electronic shutter

Video: 4K video recording, HDR and high-quality video support (H.265 / 10-bit), together with DJI's advanced gimbal stabilisation.

Additional Sensors / Safety: The drone is equipped with omnidirectional obstacle sensing and a suite of sensors.

Connectivity and Control / Communications:

Remote controller + integrated GPS/GLONASS / satellite- and sensor-assisted positioning and stabilisation

Video Transmission System: DJI OcuSync (current generation) — HD video transmission and control-signal communication

Real-time flight-data monitoring, automatic return / return-to-home, and safety features

Power and Flight Performance:

Intelligent Flight Battery: 3850 mAh (LiPo 4S) / 59.29 Wh capacity

Maximum Flight Time: ≈31 minutes (under ideal conditions)

Maximum Flight Speed: 72 km/h (≈44.7 mph)

Maximum take-off / landing control, stable hovering, GPS-assisted position holding / return, safe landing, and autonomous mission modes

Applications and Areas of Use:

Aerial photography and video recording (4K / high-resolution photography)

Mapping, land surveying, agriculture, infrastructure inspection, and field inspection

Image processing, orthophoto generation, and UAV mapping

Drone programming, automation, and sensor integration for education and research

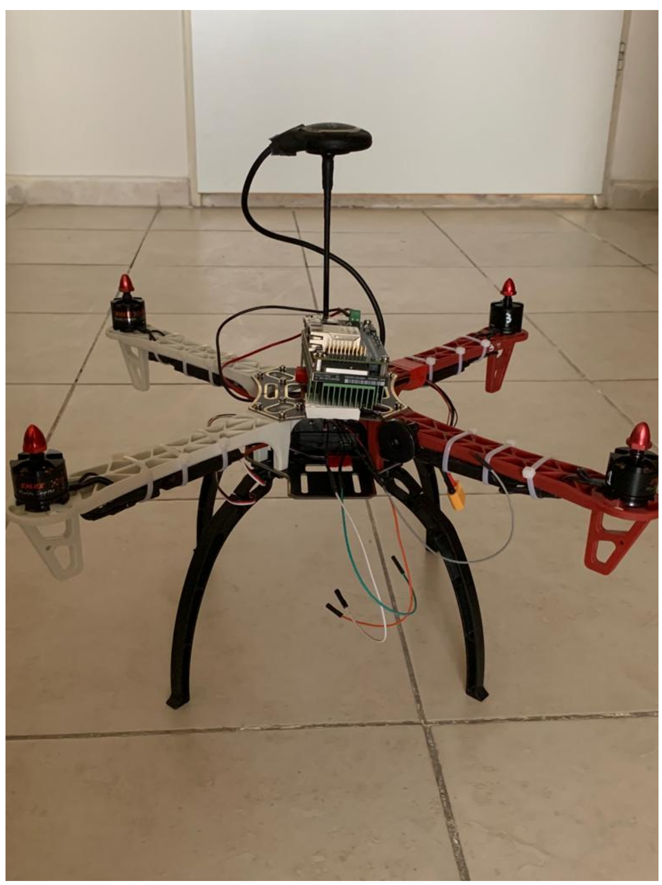
13. LIDAR AND CAMERA SENSORS

Our laboratory has 2D LiDAR, 3D LiDAR, time-of-flight (ToF) LiDAR, ZED 1 and ZED 2 cameras, and Kinect 1 and Kinect 2 cameras. A Raspberry Pi camera and a FLIR Dev Kit thermal camera are also available.

14. EMBEDDED COMPUTING BOARDS

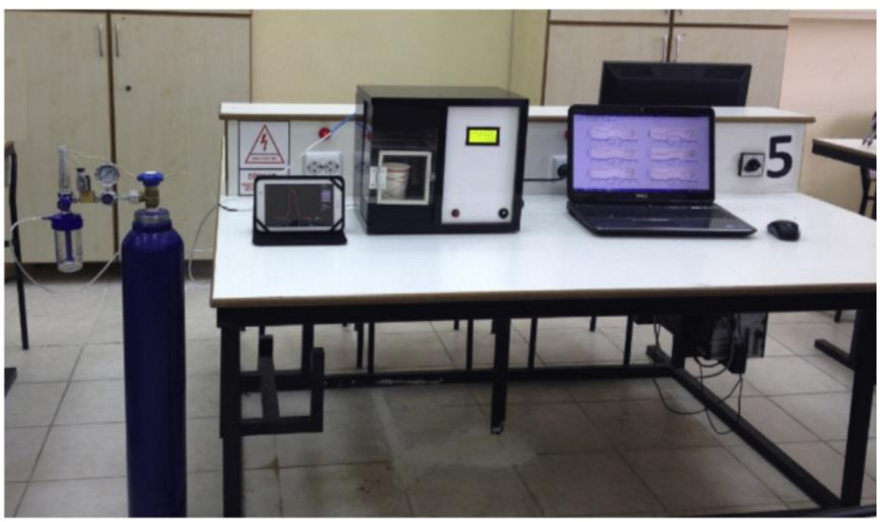
Various Jetson TX1, Jetson TX2, Jetson AGX Orin, Raspberry Pi, and Arduino boards are available in our laboratory.

15- CUSTOM-BUILT UNMANNED AERIAL VEHICLE POWERED BY JETSON TX2



16- CUSTOM-BUILT FLYING BIRD

17. AI-ASSISTED ELECTRONIC NOSE



18. AUTONOMOUS WHEELCHAIR

19. COMPUTERS

Our laboratory has two laptops and three desktop computers equipped with NVIDIA graphics cards, acquired between 2014 and 2024.

20. SENSORS

Our laboratory has a remote communication kit, various IMU and Pixhawk sensors, and autopilot systems.