Kits robóticos y robots paradigmáticos

Fundamentos de Robótica Autónoma

MINA - Facultad de Ingeniería - Udelar

Contenido

1. Kits robóticos
    a. Motivación
    b. Historia
    c. Mindstorms
    d. Butiá SAM (2.0)
2. Robots paradigmáticos

Kits: motivación

Los Kits son muy importantes en la robótica educativa y el prototipado

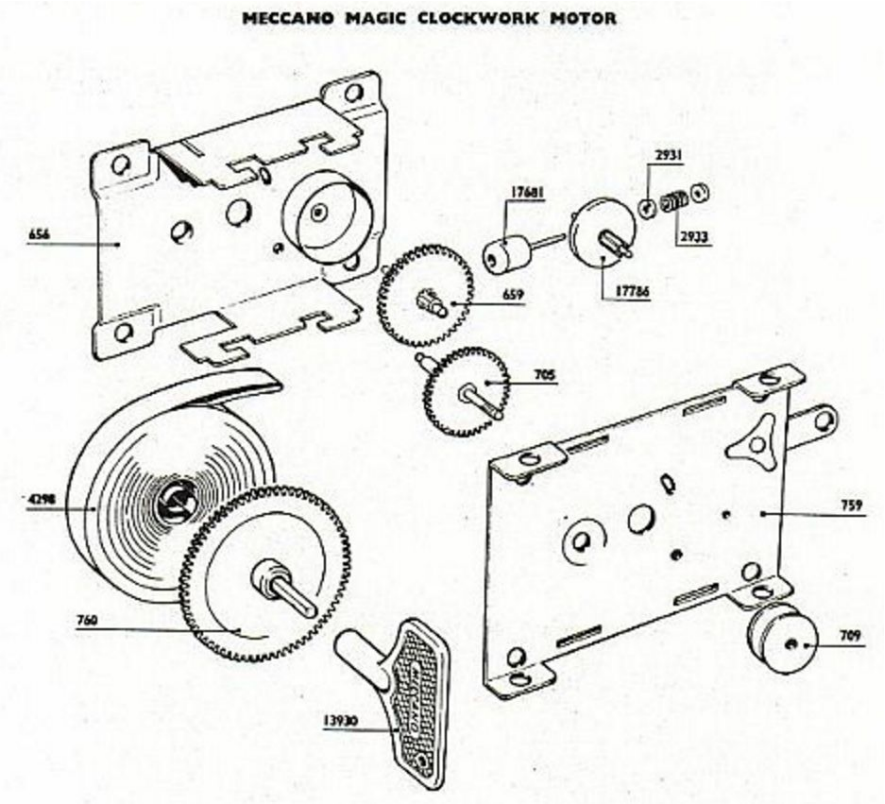
- Estandarizan los componentes mecánicos y electrónicos para simplificar la construcción y programación de un robot.
- Utilizados fuertemente para estimular el interés por disciplinas científicas, las llamadas STEM: Science, Technology, Engineering and Mathematics.

Algunos ejemplos históricos

En 1901 Frank Hornby, inventa y patenta un nuevo juguete llamado "Mechanics Made Easy"

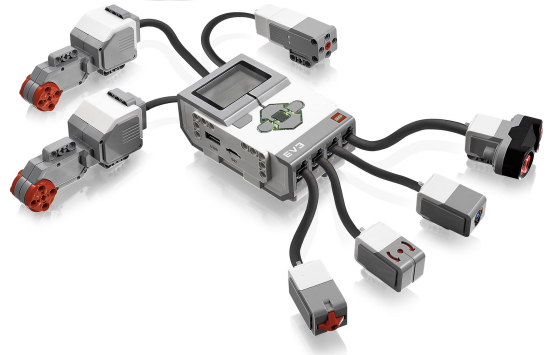
Algunos ejemplos históricos

Magic Clockwork motor M1
(introducido en 1935)
implementando con un resorte que permite almacenar energía cuando se enrolla, y volverla a dar durante la expansión.



Mindstorms: historia

- LEGO clásico: 1949
- Diseño actual: 1958
- Plástico ABS desde 1963
- LEGO Technic: 1982
  - Nuevas piezas, motores, engranajes, luces…
- Mindstorms
  - RIS: 1998
  - Mindstorms NXT: 2006
  - Mindstorms NXT 2.0: 2009
  - Mindstorms EV3: 2013
  - RIP: 2022



RIS, NXT & EV3

- Ladrillos y piezas Technic
- Controlador: RCX, NXT y EV3
- Sensores
- Motores
- Comunicación
- Software
- Alimentación

NXT: Controlador

Microcontrolador ARM7 32-bit, a 48MHz

- 256KB FLASH, 64Kb RAM

Microcontrolador auxiliar AVR 8-bit a 8MHz

- Control de los motores (modulación PWM)
- 4KB FLASH, 512B RAM

Bluetooth (SPP) + USB 2.0

3 Salidas

4 Entradas

LCD, botones, parlante

6 pilas AA o Pack NiMH de 7.2V

NXT: Sensores

Contacto (#2 en NXT 2.0)

- press/release/bump

Luz (solo en NXT 1.0)

- Luz ambiente, reflejada
- monocromático

Sonido (solo en NXT 1.0)

- dB y dBA, en %.

Ultrasonido

- distancias 0-255cm+/- 3cm

NXT: Sensores

Color (solo en NXT 2.0)

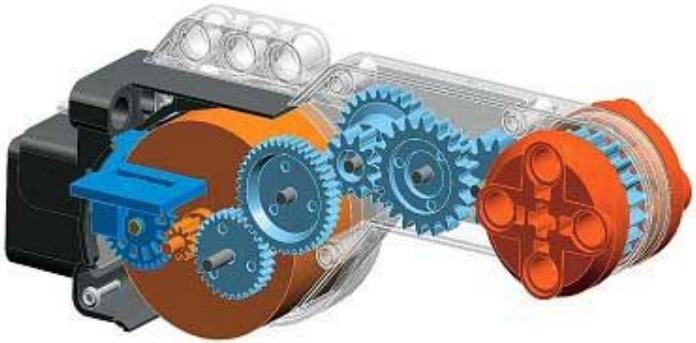
- Modo detección de color
- Modo medición de luz ambiente, reflejada

Existen muchos sensores más no incluidos en el kit básico

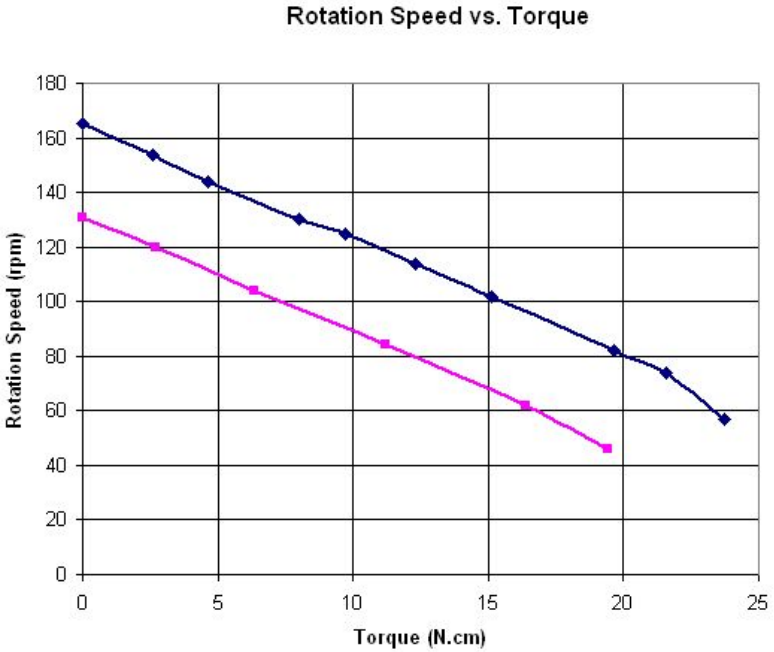
NXT: Motores

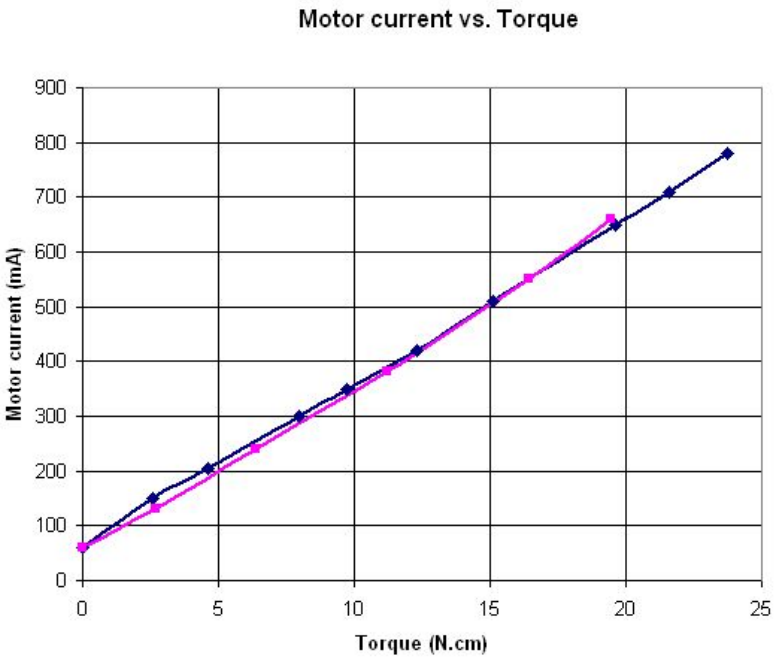
Servomotores con feedback:

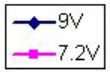
- Reducción integrada
- Control:
  - Rotación contínua
  - Angulo
- 0 a 165 RPM controlados de forma lineal @9V (sin carga)
- 0 a 130 RPM controlados de forma lineal @7.2(bateria de NiMH) (sin carga)
- Encoder integrado (1° precisión)



NXT: Motores


Rotation Speed vs. Torque
Rotation Speed (rpm)
180
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
Torque (N.cm)


Motor current vs. Torque
Motor current (mA)
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Torque (N.cm)


9V
7.2V

Programación

El Controlador NXT está basado en un microcontrolador, lo que implica capacidades de cómputo muy limitadas (64KB RAM!).

- Modelo de programación en PC -> compilar -> Instalar -> correr
- Teleoperación

El controlador EV3 usa un microprocesador (muy pequeño) corriendo Linux:

- ARM9 de 300MHz
- 64MB RAM
- 16MB Flash

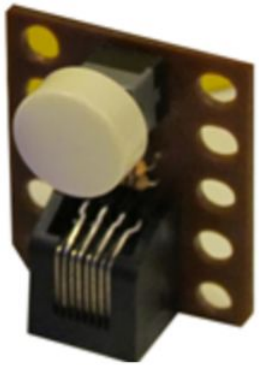
Butiá 2 SAM (2012)

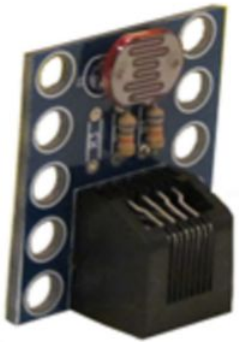
Plataforma que expande capacidad sensorial y de actuación de una computadora portátil

- Desarrollada en FING
- Licencia GNU/GPLv3

Sensores

Contacto, Grises, Luz, Distancia





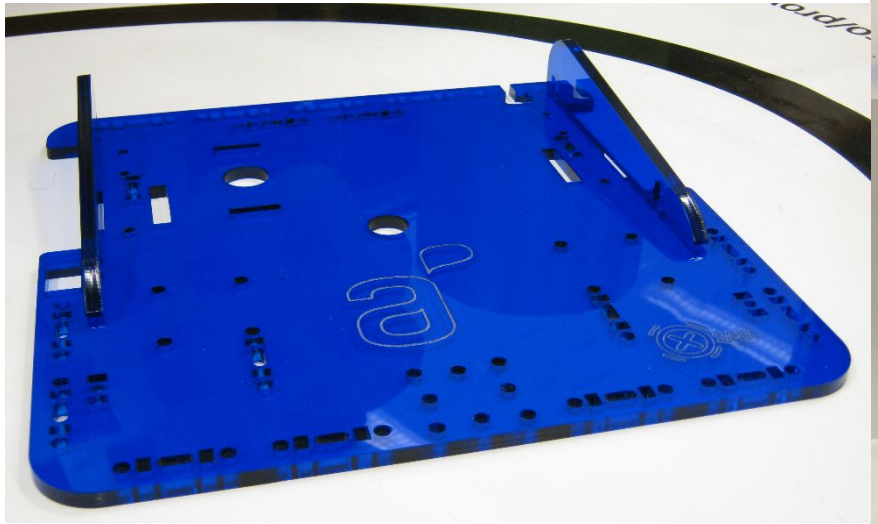
Motores

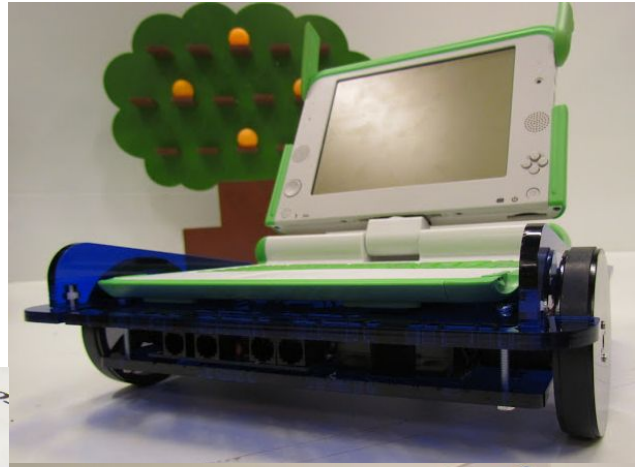
Motorreductores, Dynamixel AX-12

Piezas

Plataforma, chassis, barandas

- Acrílico 6mm, PVC, madera

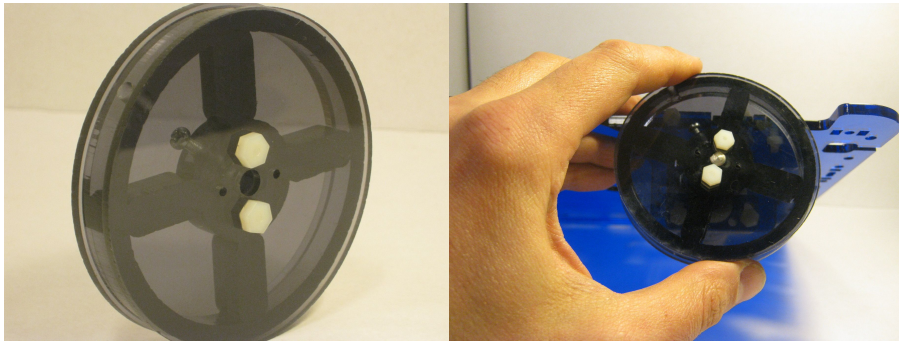




Ruedas

Componente sorprendentemente caro y/o complicado de fabricar:

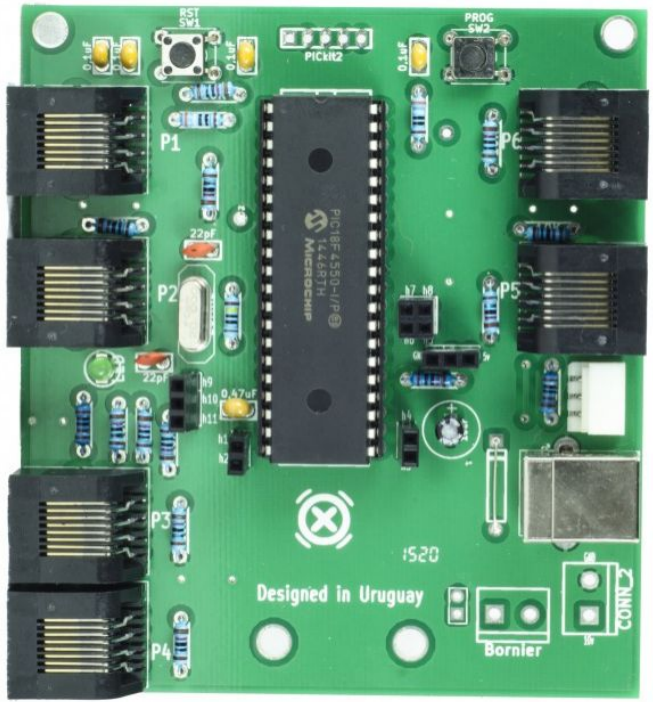
- 3 piezas: llanta, tapas, aro de goma
- Diámetro 92mm, pisada 9mm
- → Perimetro = 2*PI*R = 257.5mm
  → Una vuelta recorre 0.26m
  → si motor de 80 RPM,
  Velocidad de Butiá = 0.35 m/s



USB4Butiá

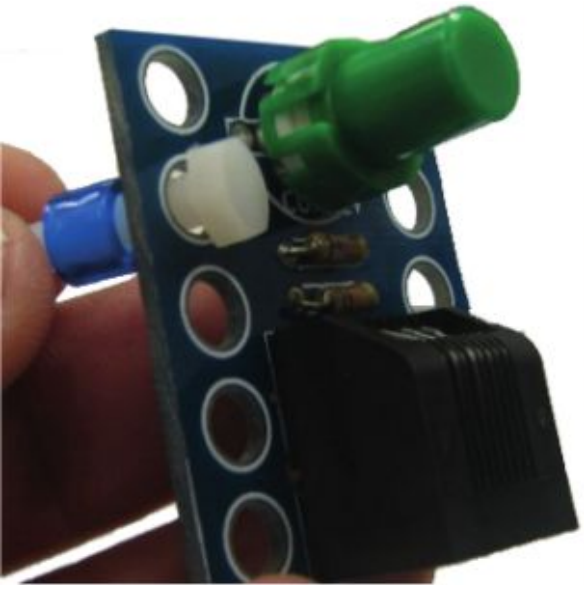
- 6 puertos generales de E/S
- Microcontrolador PIC18
- plug&play de sensores
- Expansión mediante *hackpines*
- Bus para controlar motores AX12
- Conexión USB

Integrado a IDEs educativas, e.g. Turtlebots.



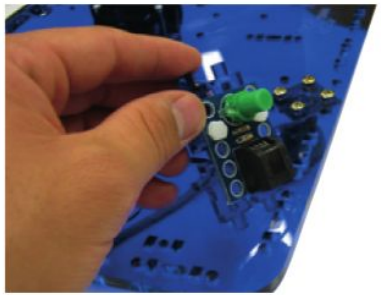
Sistema de encastre

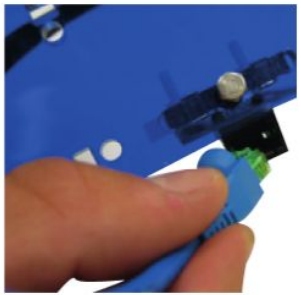
Los sensores se montan sobre la ficha de encastre usando tornillos y tuercas

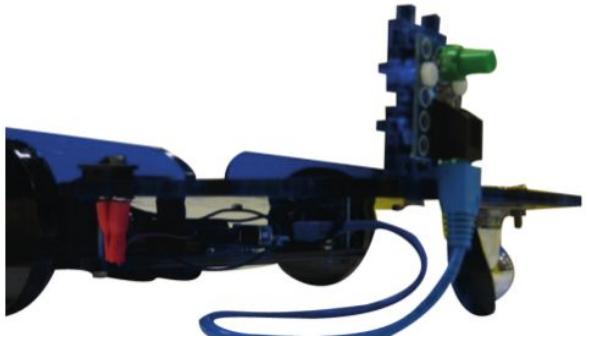


Sistema de encastre

Luego se monta sobre la plataforma, usando solo un tornillo y una tuerca, y se conecta el sensor a la placa USB4Butiá



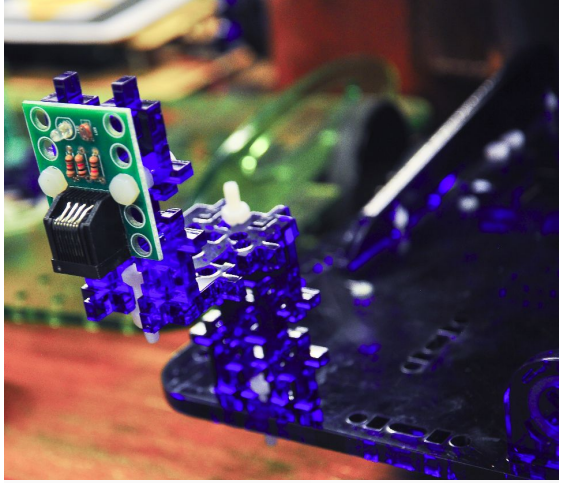


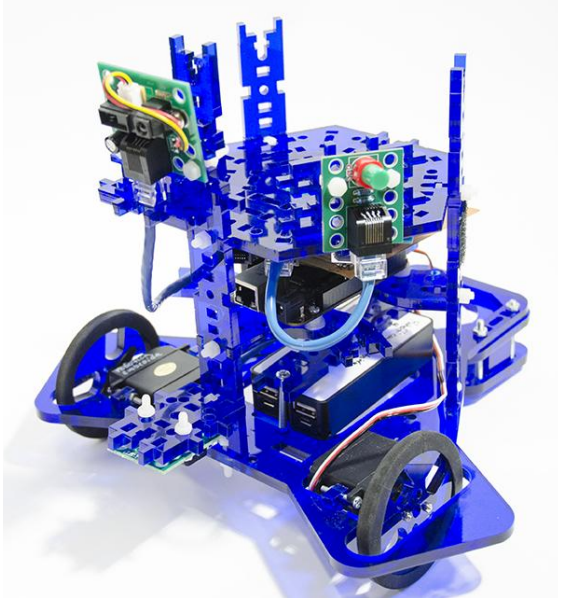


Sistema de encastre

Es posible conectar varias fichas entre sí, formando estructuras más complejas.

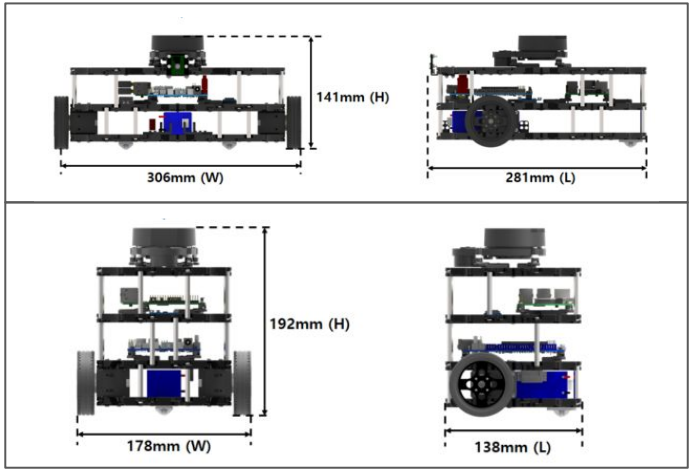
Extendido a nuevos *form-factors* con Butiá3 (2015)





Algunos robots paradigmáticos

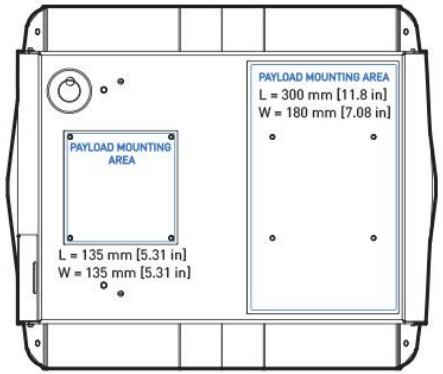
Robotis TurtleBot3 (2017)



Items	Burger	Waffle Pi
Maximum translational velocity	0.22 m/s	0.26 m/s
Maximum rotational velocity	2.84 rad/s (162.72 deg/s)	1.82 rad/s (104.27 deg/s)
Maximum payload	15kg	30kg
Size (L x W x H)	138mm x 178mm x 192mm	281mm x 306mm x 141mm
Weight (+ SBC + Battery + Sensors)	1kg	1.8kg
Climbing Threshold	10 mm or lower	10 mm or lower
Expected operating time	2h 30m	2h
Expected charging time	2h 30m	2h 30m
SBC (Single Board Computer)	Raspberry Pi 4	Raspberry Pi 4
MCU	32-bit ARM Cortex®-M7 with FPU (216 MHz, 462 DMIPS)	32-bit ARM Cortex®-M7 with FPU (216 MHz, 462 DMIPS)
Remote Controller	-	RC-100B + BT-410 Set (Bluetooth 4, BLE)
Actuator	XL430-W250	XM430-W210
LDS (Laser Distance Sensor)	360 Laser Distance Sensor LDS-02	360 Laser Distance Sensor LDS-02
Camera	-	Raspberry Pi Camera Module v2.1
IMU	Gyroscope 3 Axis Accelerometer 3 Axis	Gyroscope 3 Axis Accelerometer 3 Axis
Power connectors	3.3V / 800mA 5V / 4A 12V / 1A	3.3V / 800mA 5V / 4A 12V / 1A
Expansion pins	GPIO 18 pins Arduino 32 pin	GPIO 18 pins Arduino 32 pin
Peripheral Connections	UART x3, CAN x1, SPI x1, I2C x1, ADC x5, 5pin OLLO x4	UART x3, CAN x1, SPI x1, I2C x1, ADC x5, 5pin OLLO x4
DYNAMIXEL ports	RS485 x 3, TTL x 3	RS485 x 3, TTL x 3
Audio	Several programmable beep sequences	Several programmable beep sequences
Programmable LEDs	User LED x 4	User LED x 4
Status LEDs	Board status LED x 1 Arduino LED x 1 Power LED x 1	Board status LED x 1 Arduino LED x 1 Power LED x 1
Buttons and Switches	Push buttons x 2, Reset button x 1, Dip switch x 2	Push buttons x 2, Reset button x 1, Dip switch x 2
Battery	Lithium polymer 11.1V 1800mAh / 19.98Wh 5C	Lithium polymer 11.1V 1800mAh / 19.98Wh 5C
PC Connection	USB	USB
Firmware Upgrade	via USB / via JTAG	via USB / via JTAG
Power Adapter (SMPS)	Input : 100-240V, AC 50/60Hz, 1.5A @max Output : 12V DC, 5A	Input : 100-240V, AC 50/60Hz, 1.5A @max Output : 12V DC, 5A

Clearpath Robotics: Jackal UGV

“Jackal is a small, fast, entry-level field robotics research platform. It has an onboard computer, GPS and IMU fully integrated with ROS for out-of-the-box autonomous capability. As with all Clearpath robots, Jackal is plug-and-play compatible with a huge list of robot accessories to quickly expand your research and development.”



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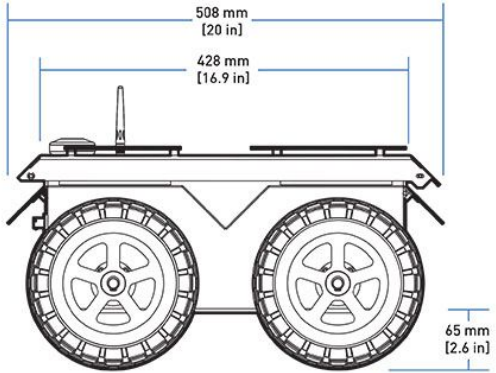
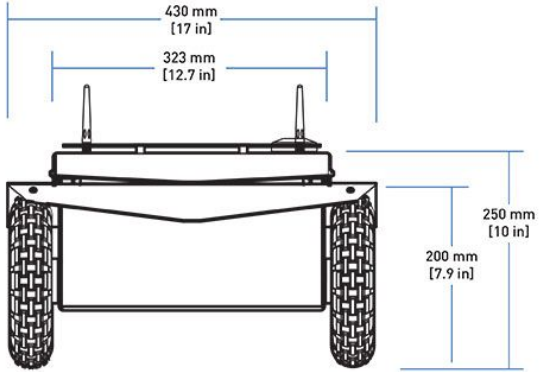


SIDE



FRONT

Clearpath Robotics: Jackal UGV

SIZE AND WEIGHT		
EXTERNAL DIMENSIONS (L x W x H)	508 x 430 x 250 mm (20 x 17 x 10 in)	
INTERNAL STORAGE DIMENSIONS	250 x 100 x 85 mm (10 x 4 x 3 in)	
WEIGHT	17 kg (37 lbs)	
GROUND CLEARANCE	65 mm (2.6 in)	
SPEED AND PERFORMANCE		
MAX. PAYLOAD	20 kg (44 lbs)	
ALL-TERRAIN PAYLOAD	10 kg (22 lbs)	
MAX. SPEED	2.0 m/s (6.6 ft/s)	
DRIVE POWER	500 W	
BATTERY AND POWER SYSTEM		
BATTERY CHEMISTRY	Lithium Ion	
CAPACITY	270 Watt hours	
CHARGE TIME	4 hours	
RUN TIME	Heavy usage: 2 hours	Basic Usage: 8 hours
USER POWER	5 V at 5 A, 12 V at 10 A, 24 V at 20 A	
INTERFACING AND COMMUNICATION		
CONTROL MODES	Kinematic Commands — velocity, angular velocity Open Loop Motor Driver Commands — voltage Wheel Velocity Commands	
FEEDBACK	Battery and motor current Wheel velocity and travel	Integrated GPS receiver Integrated gyroscope and accelerometer
COMMUNICATION	Ethernet, USB 3.0, RS232. (IEEE 1394 available)	
DRIVERS AND APIs	Packaged with ROS Kinetic	
SUPPORTED OPERATING SYSTEMS	Ubuntu, Windows	
INTEGRATED ACCESSORIES (included)	Wireless Game controller, GPS, IMU, On-Board Computer, WIFI Adapter, Accessory Mounting Plates	
COMPUTER	**Standard**	**Performance**
	i3-4330TE Dual core, 2.4GHz 4 GB RAM WIFI Adapter 120 GB Hard Drive	Intel Core i5 4570T Dual core, 2.9GHz 4 GB RAM WIFI Adapter 128GB Hard Drive
ENVIRONMENTAL		
OPERATING AMBIENT TEMPERATURE	-20 to 45 °C (-4 to 113 °F)	

Version

Basic (Intel i3-4330TE CPU + 4GB RAM) + € 0,

€ 17.492,95

incl. 19% VAT , plus shipping costs

Manufacturers recommended retail price: € 18.207,00
(Save 3.92%, i.e. € 714,05)

Available immediately

Delivery time: 15 - 18 Workdays (DE - int. shipments may differ)

Boston Dynamics Spot

DIMENSIONS

Length
1100 mm (43.3 in)

Width
500 mm (19.7 in)

Height (Sitting)
191 mm (7.5 in)

Default Height (Walking)
610 mm (24.0 in)

Max Height (Walking)
700 mm (27.6 in)

Min Height (Walking)
520 mm (20.5 in)

Net Mass/Weight (Spot with battery)
32.7 kg (72.1 lbs)

LOCOMOTION

Max Speed
1.6 m/s

Max Slope
±30°

Max Step Height
300 mm (11.8 in)

ENVIRONMENT

Ingress Protection
IP54

Operating Temp.
-20°C to 55°C

BATTERY

Battery Capacity
564 Wh

Average Runtime*
90 mins

Standby Time
180 mins

Recharge Time
60 mins

Length
324 mm (12.8 in)

Width
168 mm (6.6 in)

Height
93 mm (3.7 in)

Mass/Weight
5.2 kg (11.5 lbs)

PAYLOAD MOUNTING

Max Weight
14 kg (30.9 lbs)

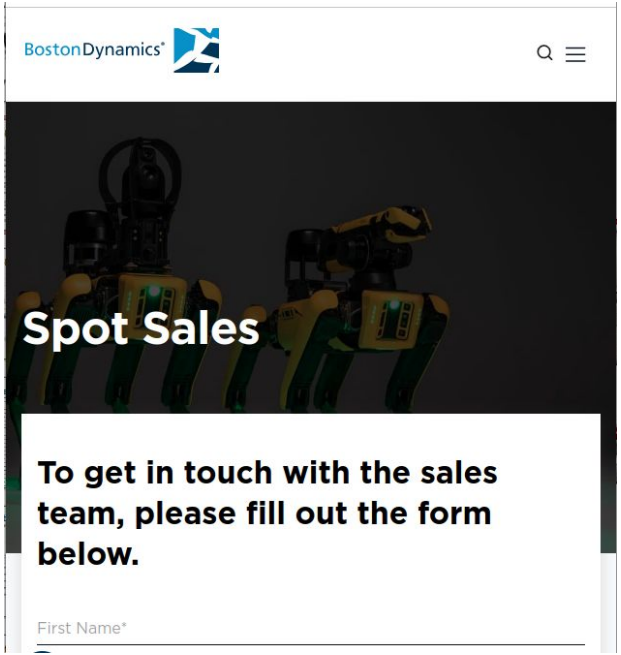
Mounting Area
850 mm (L) x 240 mm (W) x 270 mm (H)

Mounting Interface
M5 T-slot rails

Connector
DB25 (2 ports)

Power Supply
Unregulated DC 35-58.8V, 150W per port

Integration
Available software API and hardware interface control document



LEGO Ideas: Boston Dynamics Spot Robot Building Set
Totalmente nuevo
UYU $328.58
¡Cómpralo ahora!
Envío internacional gratis de China
essentialpromotions (86) 82,8%

Unitree Go2

	Type	AIR	PRO	EDU
Mechanical & Electron	Stand Height	70×31×40cm		
	Weight (With Battery)	About 15kg		
	Material	Aluminium alloy + High strength engineering plastic		
	Voltage	28V~33.6V		
	Peaking Capacity	About 3000W		
Performance	Payload	≈7kg (MAX ~ 10kg)	≈8kg (MAX ~ 10kg)	≈8kg (MAX ~ 12kg)
	Speed	0~2.5m/s	0~3.5m/s	0~3.7m/s (MAX~5m/s)
	Max Climb Drop Height	About 15cm	About 16cm	
	Max Climb Angle	30°	40°	
	Basic Computing Power	○	8-core High-performance CPU	
Joint	Peak Joint Torque [1]	○	About 45N.m	
	Range of motion	Body: -48~48°	Thigh: -200°~90°	Shank: -156°~-48°
	Intra-joint circuit (knee)	●	●	●
	Joint Heat Pipe Cooler	●	●	●
	Secondary development [2]	○	○	●
Accessories	Manual controller	Optional		Standard
	High computing power modular	○		Optional Nvidia Jetson Orin
	Smart battery	Standard (8000mAh)		Long endurance (15000mAh)
	Endurance	About 1-2h		About 2-4h
	Charger	Standard (33.6V 3.5A)		Fast charge (33.6V 9A)

$2,800.00 USD

Order now and ship within 1 months

Shipping costs $399 per unit, Remote Countries $499-$1000

Not include customs duties, Please comply with local customs laws pay customs duties and clear the goods

Contact sales to get Go2 Edu price

Version

Go2 Pro (without controller) | Go2 Pro (with controller)

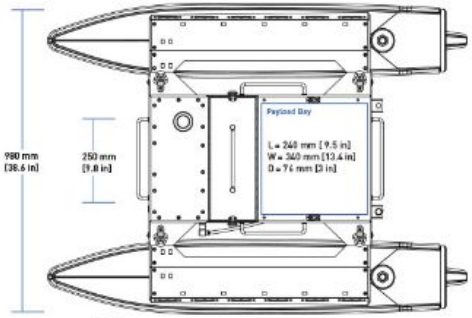
Go2 Air (without controller) | Go2 Air (with controller)

Unitree G1

Joint motor	Low inertia high-speed internal rotor PMSM(permanent magnet synchronous motor,better response speed and heat dissipation)
Maximum Torque of Knee Joint【1】	90N.m
Arm Maximum Load【2】	About 2Kg
Calf + Thigh Length	0.6M
Arm Span	About 0.45M
Extra Large Joint Movement Space	Waist joint：Z±155° Knee joint：0~165° Hip joint：P±154°、R-30~+170°、Y±158°
Full Joint Hollow Electrical Routing	YES
Joint Encoder	Dual encoder
Cooling System	Local air cooling
Power Supply	13 string lithium battery
Basic Computing Power	8-core high-performance CPU
Sensing Sensor	Depth Camera+3D LiDAR

Height, Width and Thickness（Stand）	1320x450x200mm
Height, Width and Thickness（Fold）	690x450x300mm
Weight (With Battery)	About 35kg
Total Degrees of Freedom（Joint Freedom）	23
Single Leg Degrees of Freedom	6
Waist Degrees of Freedom	1
Single Arm Degrees of Freedom	5
Smart Battery (Quick Release)	9000mAh
Charger	54V 5A
Manual Controller	YES
Battery Life	About 2h
Upgraded Intelligent OTA	YES
Secondary Development【3】	/
Warranty Period【4】	8 months
Price(Tax and Shipping cost excluded)	US $16K

Clearpath Robotics: Heron USV



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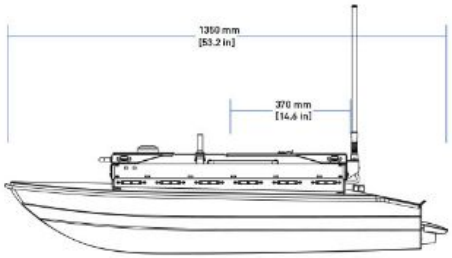

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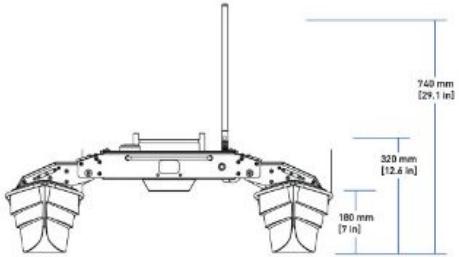

FRONT

DIMENSIONS DEPLOYED (L x W x H)	1350 x 980 x 320 mm (53.2 x 38.6 x 12.6 in)	**DRAUGHT**	120 mm (4.7 in)	**PROPULSION**	Water Jet (Electric)
DIMENSIONS STORED (L x W x H)	1350 x 560 x 330 mm (53.2 x 22 x 13 in)	**BATTERY PACK**	NiMH 14.4V 29Ah 2.5 hrs life	**ENVIRONMENTAL**	IP 65 - 10 / +30 °C
WEIGHT	28 kg (62 lbs)	**DRIVE POWER**	70 W peak 40 N Thrust	**SENSORS**	GPS, IMU
RATED PAYLOAD	10 kg (22 lbs)	**RECHARGE TIME**	8 hrs	**DRIVERS/ APIs**	ROS, C++, MOOS-IvP
MAXIMUM SPEED	1.7 m/s (3.3 kn)	**COMMUNICATION**	Ethernet, RS232	**CONTROL MODES**	TELE-OP. PROGRAMMABLE. GPS NAVIGATION

¿Preguntas?