



# **Hardware: Locomotions & Mechanical Design (2- ACTUATORS)**

# Hardware Components that move the Robots

## i) Basic Motion Principle

## ii) Hardware Components (Specification, Brands and Price)

### 1) Stationary Robots

- a) Omron forpheus robot

### 2) Wheeled Robots & Tracked Robots

- a) Single wheel BB-8
- b) 4WD Omni-Directional Mobile Robot
- c) Wall Climbing Robot (Metal vs Wall vs Glass)

### 3) Legged

- a) Humanoid Robot (BIOLOID)

### 4) Swimming

- a) Fish robot
- b) Underwater glider robot

### 5) Others

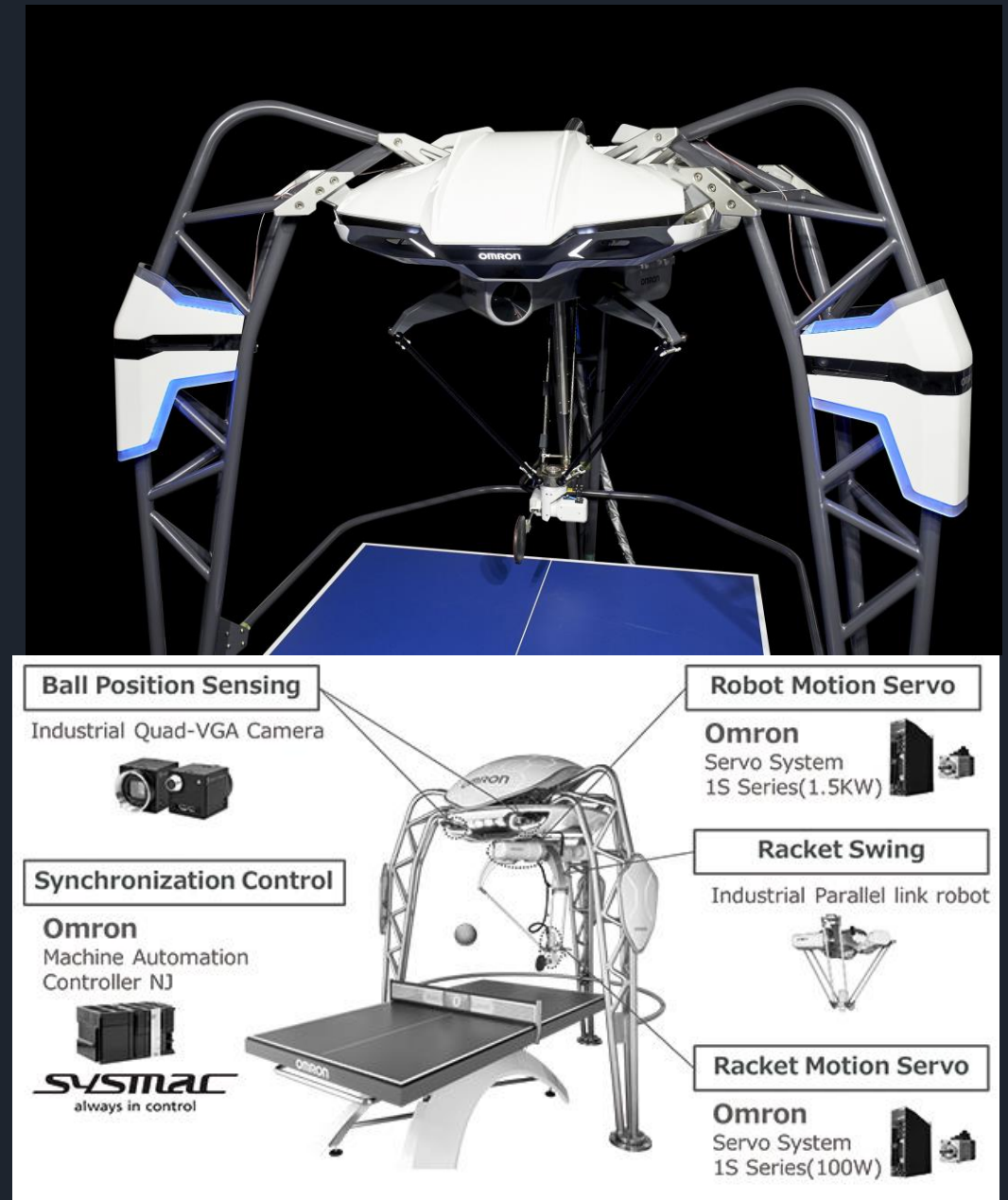
- a) Kilobot

# 1) Stationary Robots

## a) Omron forpheus robot

- Basic motion principle

In OMRON Forpheus robots, The motion sensor identifies the movement of the opponent. A controller can analyze speed at one thousand times a second. It also features an array of cameras that are situated above the ping pong table which monitors the position of the ball. Based on the feedback, the robot motion servo and racket motion servo will determine the positions of the industrial link and the racket.

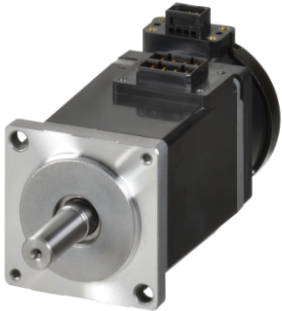


# 1) Stationary Robots

## a) Omron forpheus robot

- Hardware components

The robot uses servo system to control the motion of the robot and the racket. Where the robot motion uses a 1S series (1.5KW) system, while the racket system uses 1S series (100W)



**R88M-1M10030T-S2** [More models in this series](#)

**\$1,368.71**


ex. GST

1S AC servo motor, 100 W, 230 VAC, 3000 rpm, 0.318 Nm, absolute encoder

1 [Add To Cart](#)

0 - 2 units	Available immediately as of 18/04/2022
2+ units	Lead time of 22 days

Specifications: <https://store.omron.com.au/product/r8m10036a>



**R88M-1L1K530C-BS2** [More models in this series](#)

**\$3,680.68**

ex. GST

1S AC servo motor, 1.5 kW, 400 VAC, 3000 rpm, 4.77 Nm, absolute encoder, with brake

1 [Add To Cart](#)

0 - 1 units	Available immediately as of 18/04/2022
1+ unit	Lead time of 22 days

Specifications: <https://store.omron.com.au/product/r8m10062m>



## 2) Wheeled Robots & Tracked Robots

### a) Single wheel BB-8

- Uses gyroscope to work out which way is up, and accelerometers to determine when it's moving. Measurements from these sensors are used to make continuous adjustments so that the robot keeps its head.
- The BB-8's two Standard Motor FP13-KT electric motors



- The detailed principle can be found in the patent:  
<https://patents.google.com/patent/US20140345957>

### How toy Star Wars droid works

If you're lucky enough to own the hottest toy of the season, the Sphero BB-8 droid, you're probably wondering how it works. Here's how

The diagram illustrates the internal mechanics of the BB-8 droid. It shows a cross-section of the robot with various components labeled. The top section shows the head assembly, which is attached to the main body by magnets. The middle section shows the drive wheels and the counterweight. The bottom section shows the circuit board, which includes a gyroscope and LED lights. The diagram also shows the induction charging coil and the Bluetooth antenna.

**Head:** Attaches to sphere by **magnets**

**Inductive charging:** Electromagnetic field transfers energy to battery

**Drive wheel**

**SIDE VIEW**

**Counterweight:** Helps hold BB-8 **drive wheels** down

**High-density polycarbonate shell:** 4mm thick, slightly opaque, waterproof

**Bluetooth antenna:** Connects to smartphone. Large, to give range of 30m

**Stability:** Unpowered upper wheels

**Circuit board:** Includes gyroscope to aid orientation and flashing LED lights

**Induction charging coil**

**Drive wheels**

**Two electric motors:** These power two **drive wheels** independently, allowing them to turn in different directions and make BB-8 rotate

**Smartphone app:** Control BB-8 using iOS or Android smartphone app. Drive him with one finger or let him roam about autonomously

**Cost:** \$149.95

**Top speed:** 7.2km/h (4.5 mph)

**Battery charge:** Over 1 hour on full charge

**Height:** 11.4cm **Width:** 7.3cm **Weight:** 200g

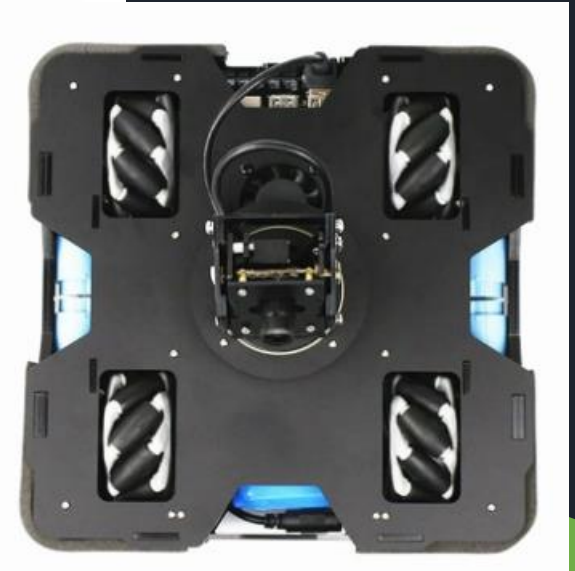
Sources: Sphero, Tested, uBreakiFix, Wired, starwars.com Picture: Lucasfilm Ltd © GRAPHIC NEWS

## 2) Wheeled Robots & Tracked Robots

### b) 4WD Omni-Directional Mobile Robot

- Working principles

Omnidirectional robots can move in all directions without steering their wheels and it can rotate clockwise and counterclockwise with reference to their axis. They use omni-wheels which are wheels with small discs (called rollers) around the circumference which are perpendicular to the turning direction. The effect is that the wheel can be driven with full force but will also slide laterally with great ease. These wheels are often employed in holonomic drive systems.



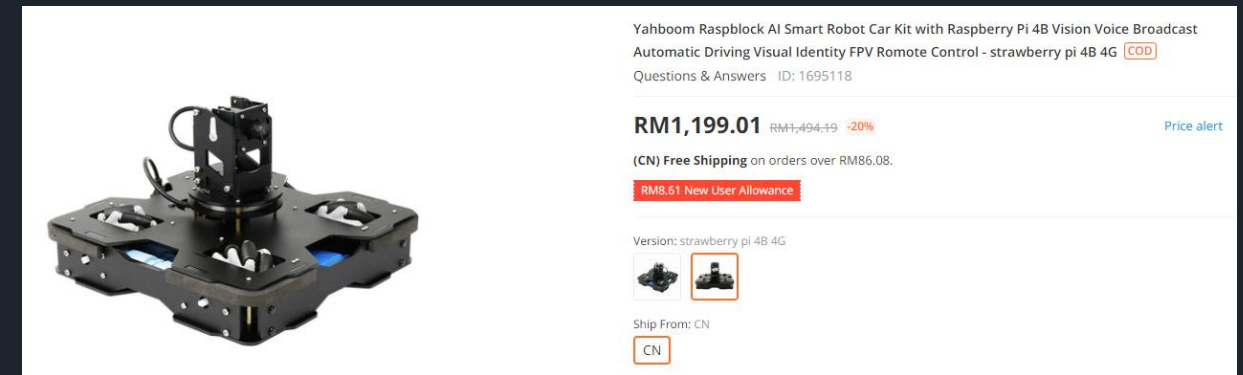
# 2) Wheeled Robots & Tracked Robots

## b) 4WD Omni-Directional Mobile Robot

### • Product specifications

- microprocessor:Raspberry Pi4B Broadcom BCM2711
- operating system:Raspberry Piofficial linux system is based on Debian
- Programming language:Python3
- Input:2 million high-definition wide-angle camera,gyroscope,encoder
- Output:Four independent motor interfaces,buzzer,horn,four PWM servo interface
- Attitude calibration:Gyro attitude calibration
- PTZ rotation:PWM servo 180 degrees left,right,up and down,manual lift
- Remote control:Moble APP(WIFI),PS2 controller(WIFI)
- Power scheme:18650 batery pack(12.6V)
- Life time:180 minutes:180 minutes
- Safety protection:reverse connection protection,overcurrent protection,low voltage alarm,voltage monitoring
- Motor:TT motor with code wheel\*4
- Communication mode:WIFI communication
- Trolley tire:Omni Wheel
- Assembly size:235\*235\*150mm(Assembly size)
- Assembly weight:1420g

### Yahboom Raspblock AI Smart Robot





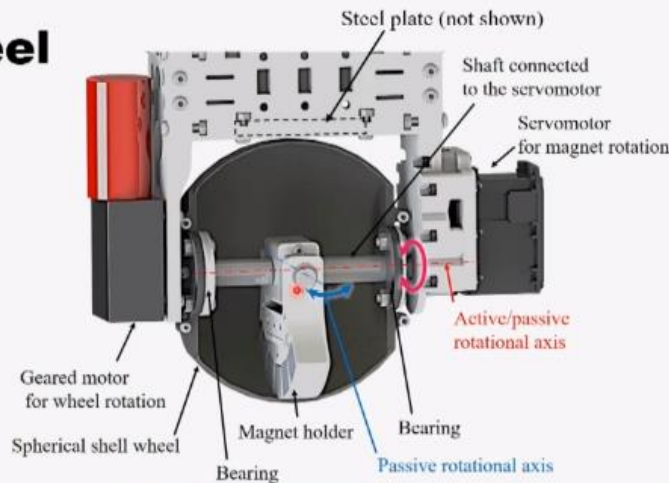
## 2) Wheeled Robots & Tracked Robots

### c) Wall Climbing Robot (**Metal** vs Wall vs Glass)

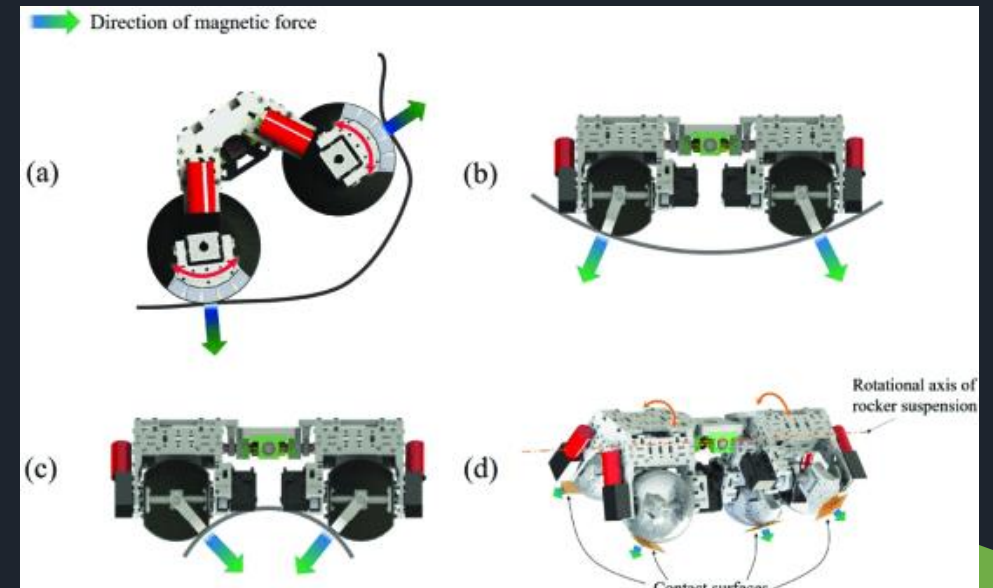
- Two main components:
  - Non-elastic suspension
  - Four spherical wheels with 2 DOF rotational magnets

#### Magnetic spherical wheel

- Spherical shell wheel made of aluminum
  - directly connected to a worm gear motor shaft
  - rubber coated
- 2 DOF rotational magnets
  - Magnet holder rotation is independent of the wheel motion
  - Switchable backdrivability
    - The shaft along the red axis is directly connected to the servo motor
    - By shutting the power supply, the servomotor becomes backdrivable
  - Rotation around the blue axis is free
- Steel plate at the bottom of frame maintains the magnet position when no magnetic force on a surface is needed



- The magnetic wheels allow the robot to climb metal wall
- The spherical structure is useful at 90 degrees corners.

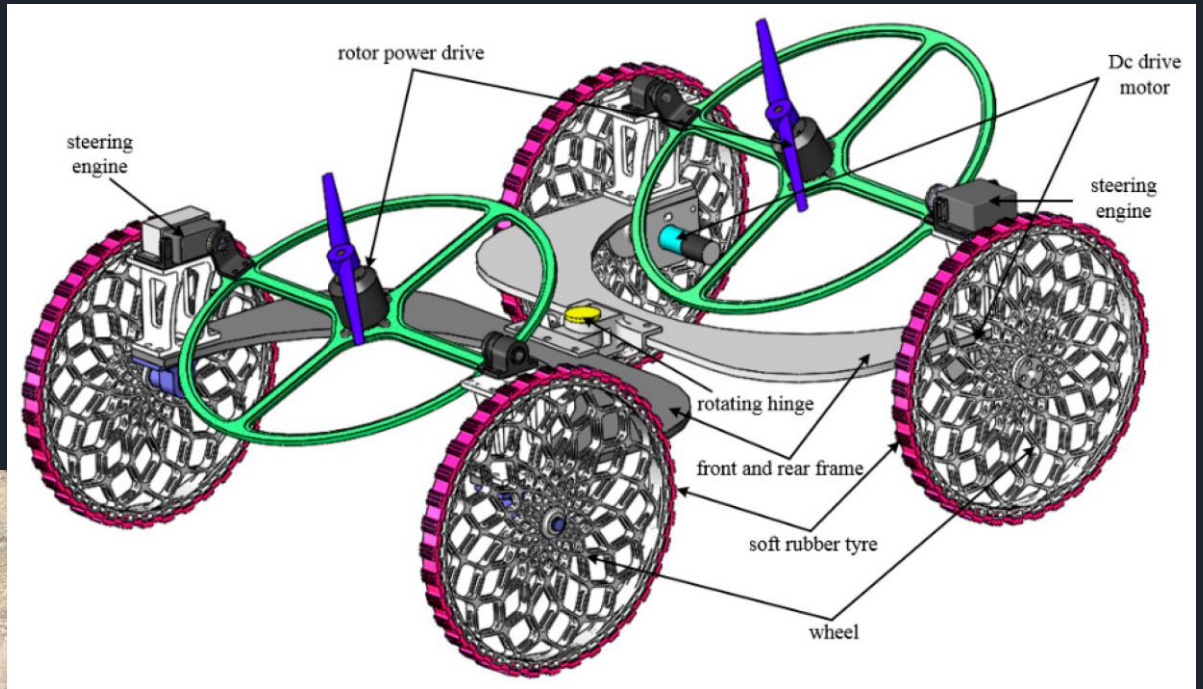
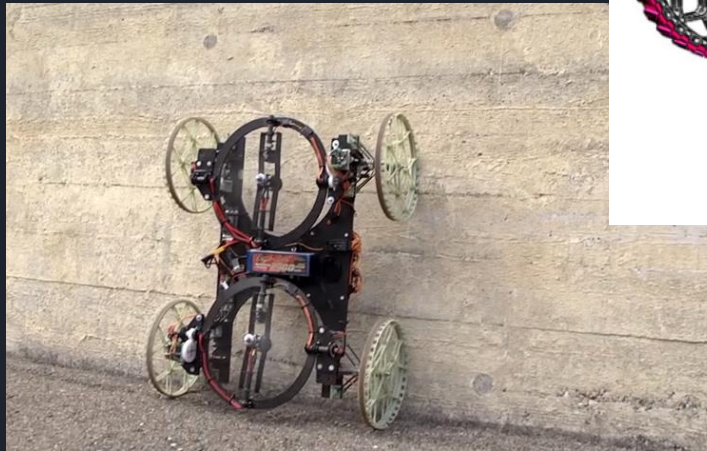




## 2) Wheeled Robots & Tracked Robots

### c) Wall Climbing Robot (Metal vs **Wall** vs Glass)

- Disney Research is developing a wall climbing robot that runs on 4 wheels.
- The robot consists of two tiltable propellers that provide the thrust.
- The pair of wheels is steerable, and each propeller has two degrees of freedom for adjusting the direction of thrust. This allows the wheels to lift and climb over objects or up walls.



## 2) Wheeled Robots & Tracked Robots

### c) Wall Climbing Robot (Metal vs **Wall** vs Glass)

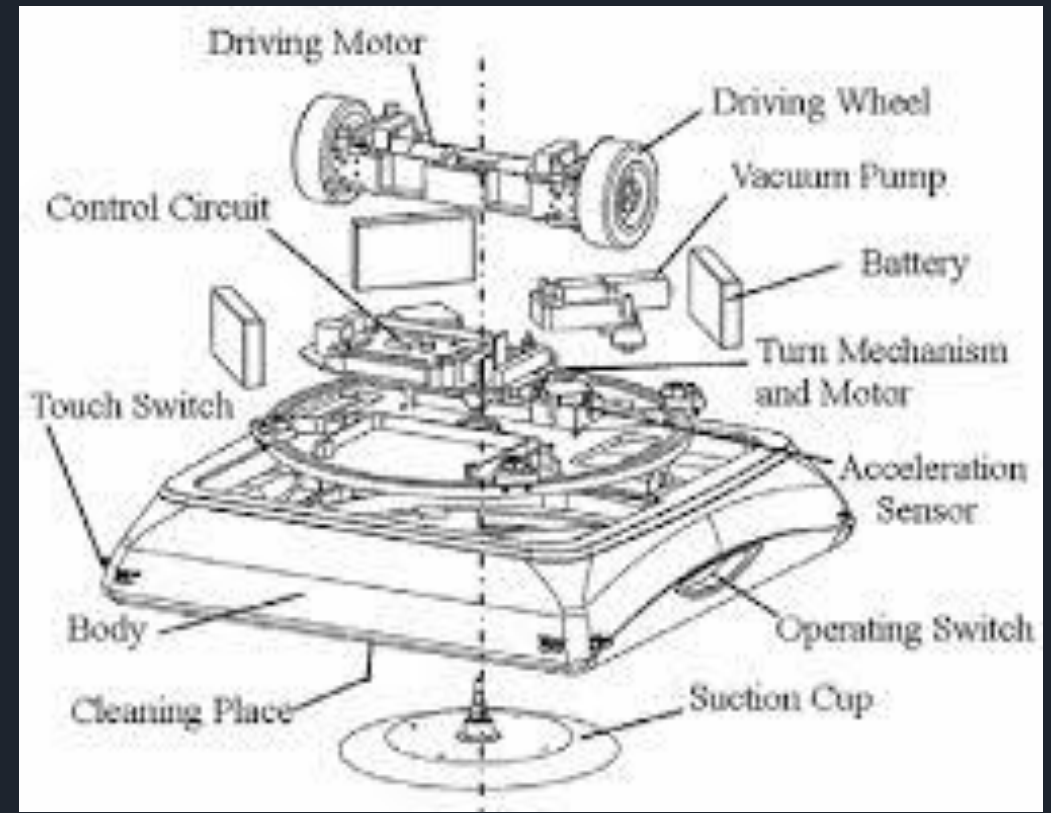
Following the same concept, HausBots wall climbing robot is utilized to perform wall inspections, painting and wall cleaning.



## 2) Wheeled Robots & Tracked Robots

### c) Wall Climbing Robot (Metal vs Wall vs Glass)

- Working principle
  - Robot window cleaners utilize motor powered suction to move around and clean your windows or any glass surfaces such as sliding doors or mirrors.
  - Robotic window cleaners either have a motor-powered suction or magnetic connectivity. With magnetic connectivity, you need to attach another magnetic piece on your window's opposite side. In some instances, this can be a bit challenging.





## 2) Wheeled Robots & Tracked Robots

### c) Wall Climbing Robot (Metal vs Wall vs Glass)

- Albohes Z5 robot

ALBOHES Z5	
Input voltage:	AC110 – 240. In
Built-in battery:	600 mAh 14.8 V
Remote control:	powered by 2 x AAA batteries (included)
Charging time:	1 hour
Product weight:	0.9300 kg
Package weight:	2.0400 kg
Product Size (L x W x H):	29.00 x 14.00 x 11.50 cm
Package size (L x W x H):	29.50 x 23.00 x 13.50 cm

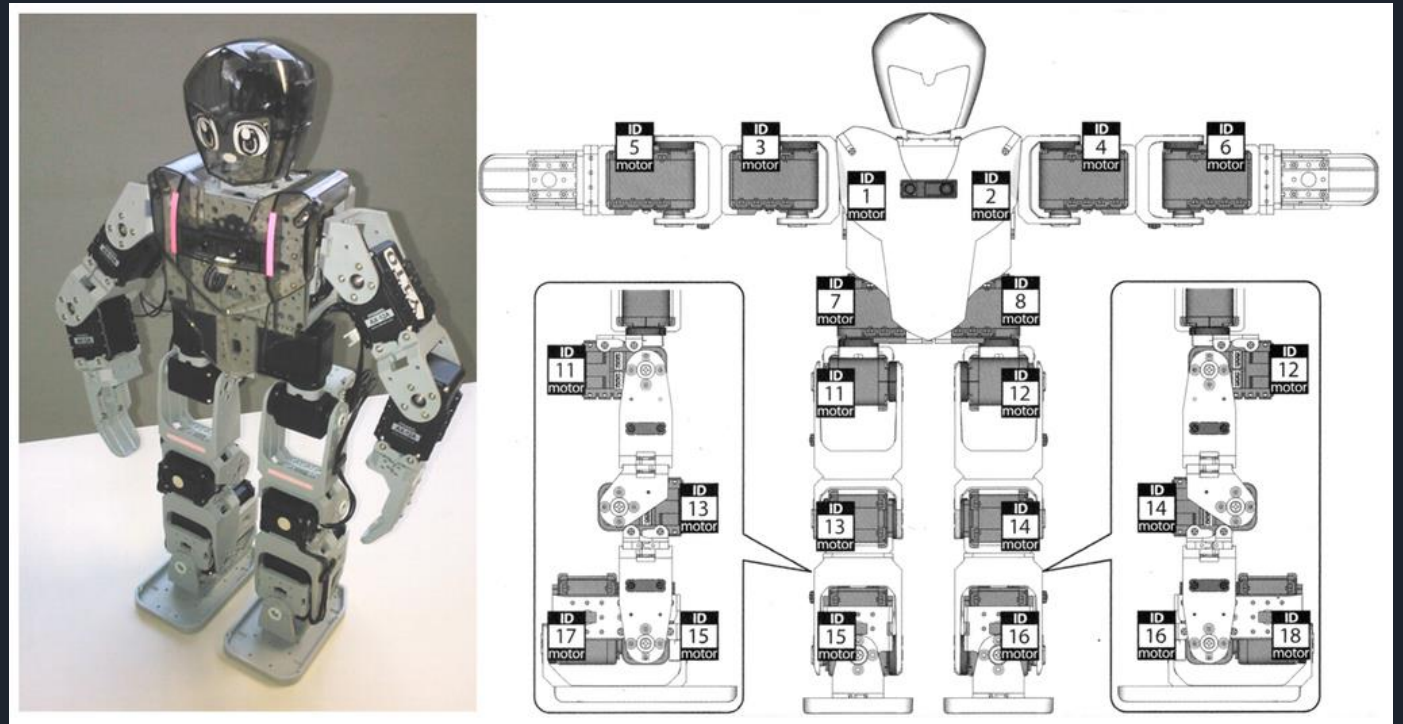




# 3) Legged

## a) Humanoid Robot (BIOLOID)

- Working principle
  - The robot consists of components and small modular servomechanisms (AX-12A Dynamixel) to control its joint movement.
  - The construction of the robot mimics the human body.



# 3) Legged

## a) Humanoid Robot (BIOLOID)

- Actuators



Item	Specifications
Baud Rate	7,843 [bps] ~ 1 [Mbps]
Weight	AX-12 (53.5 [g]), AX-12+ (53.5 [g]), AX-12A (54.6 [g])
Dimensions (W x H x D)	32 X 50 X 40 [mm] 1.26 X 1.97 X 1.57 [inch]
Resolution	0.29 [°]
Running Degree	0 ~ 300 [°] Endless Turn
Motor	Cored
Gear Ratio	254 : 1
Stall Torque	1.5 [N.m] (at 12 [V], 1.5 [A])
No Load Speed	59 [rev/min] (at 12V)
Operating Temperature	-5 ~ +70 [°C]
Input Voltage	9.0 ~ 12.0 [V] (Recommended : 11.1V)
Command Signal	Digital Packet
Physical Connection	TTL Level Multi Drop Bus Half Duplex Asynchronous Serial Communication (8bit, 1stop, No Parity)
ID	254 ID (0~253)
Feedback	Position, Temperature, Load, Input Voltage, etc
Gear Material	Engineering Plastic(Full)
Case Material	Engineering Plastic(Front, Middle, Back)

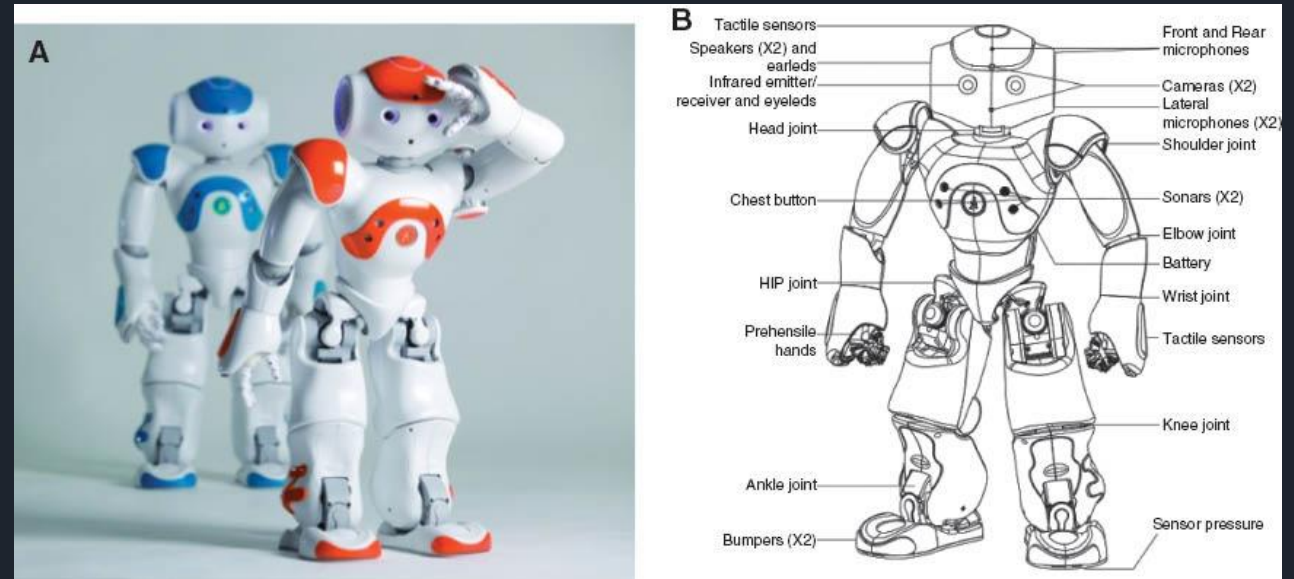
# 3) Legged

## a) Humanoid Robot (BIOLOID)

### Specificities of a Humanoid Platform: The NAO Robot

All the following methods have been applied to the humanoid robot NAO. This robot is an affordable and flexible platform. It has 25 degrees of freedom, and each motor has a magnetic rotary encoder (MRE) position sensor, which makes proprioception possible with a good precision ( $0.1^\circ$  per MRE). Its sensing system includes, in particular, two color cameras. It is equipped with an on-board Intel ATOM Z530 1.6 GHz CPU, and programmable in C++ and Python. A stable walk API is provided; however, it is based only on the joint position sensors and the inertial unit (see Ref. [6]). It is affected by the feet slipping: the robot orientation is often not precise. This API makes it possible to control the robot position and speed

**Price : \$9,000**



# 4) Swimming

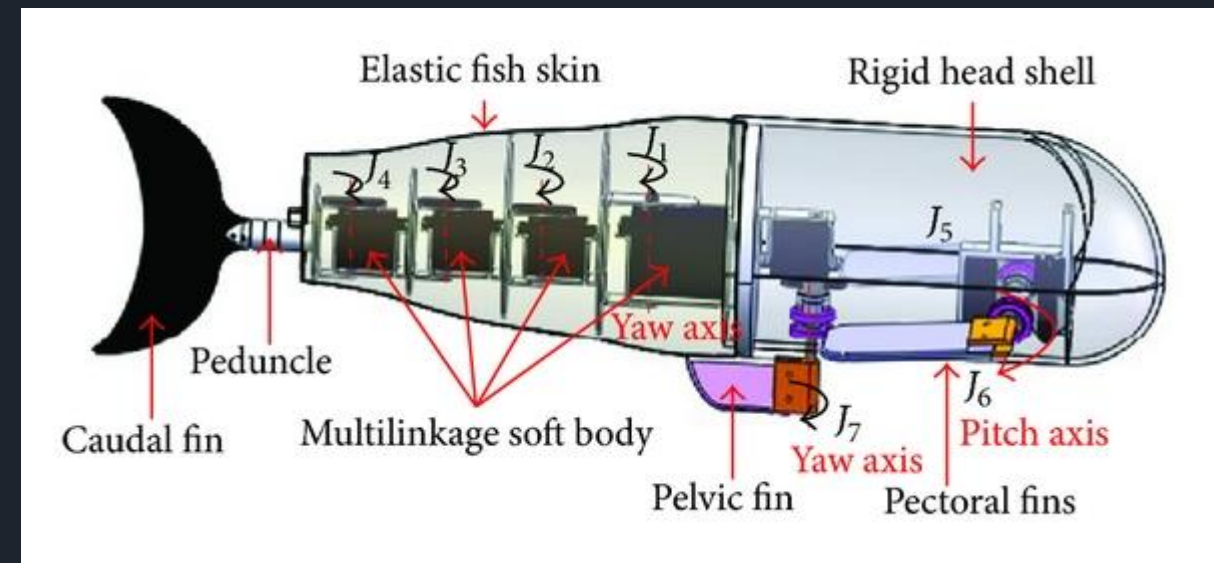
## a) Fish robot

- Working principle

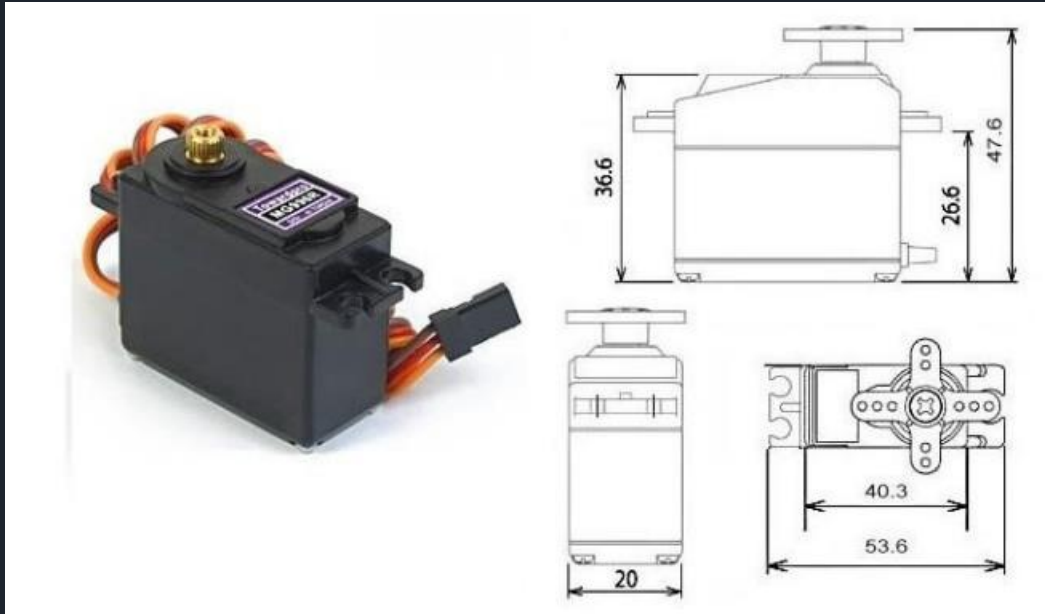
- efficient and agile swimming motions are dominantly attributed to coordinated movements of multiple control surfaces involving the body and the accessory fins. Different fins, in principle, have different functions, which complement one another. More exactly, the body plus caudal fin are responsible for propulsion and steering.
- Therefore, the design in the image places the actuators in positions to simulate fish movement

- Actuators

180-degree servomotors








## Specifications

- Weight: 55 g
  - Dimension: 40.7 x 19.7 x 42.9 mm approx.
  - Stall torque: 9.4 kgf·cm (4.8 V), 11 kgf·cm (6 V)
  - Operating speed: 0.17 s/60° (4.8 V), 0.14 s/60° (6 V)
  - Operating voltage: 4.8 V a 7.2 V
  - Running Current 500 mA -
  - Stall Current 2.5 A (6V)
  - Dead band width: 5 μs
  - Stable and shock proof double ball bearing design
  - Temperature range: 0 °C - 55 °C
- Price: RM 50

# 4) Swimming

## a) Fish robot (Jessiko by robotswim)



**Small dimensions**  
Dimensions : 230 x 85 x 105 (mm)  
Weight: 150g

**Light effects**  
4 RGB LEDs for an amazing effect at low light

**Induction charging**  
Direct positioning on charger after swimming

**Balancing and buoyancy**  
Rolling adjustment with sliding rail  
Buoyancy adjustable to salinity

**Swimming range**  
More than 9 hours continuous swimming without charging

**3D navigation**  
2 fins for smooth swimming in all directions

**Automatic unblocking**  
Forward swimming by flapping front fin in case of blocking situation

**Optical localisation**  
Patented homing head system for locating beacons and other robots

**Compatible with all types of liquids**  
Jessiko can swim in clear water, sea water, chlorine water...

**Shoal swimming**  
Tested up to 50 robots in the same school

**Jessikommand software**  
Creation of choreographies  
Calibration and diagnosis

**Connection with a smartphone**  
Wifi connection via optical beacons system

# 4) Swimming

## b) Underwater glider robot

- Working principle
- it doesn't have propellers or an internal engine. Instead, it uses a pump to gently change its buoyancy over time. This allows the glider to slowly move up and down through the water. And as it does so, the big fins sticking out of the sides of the craft create lift to propel it forward.

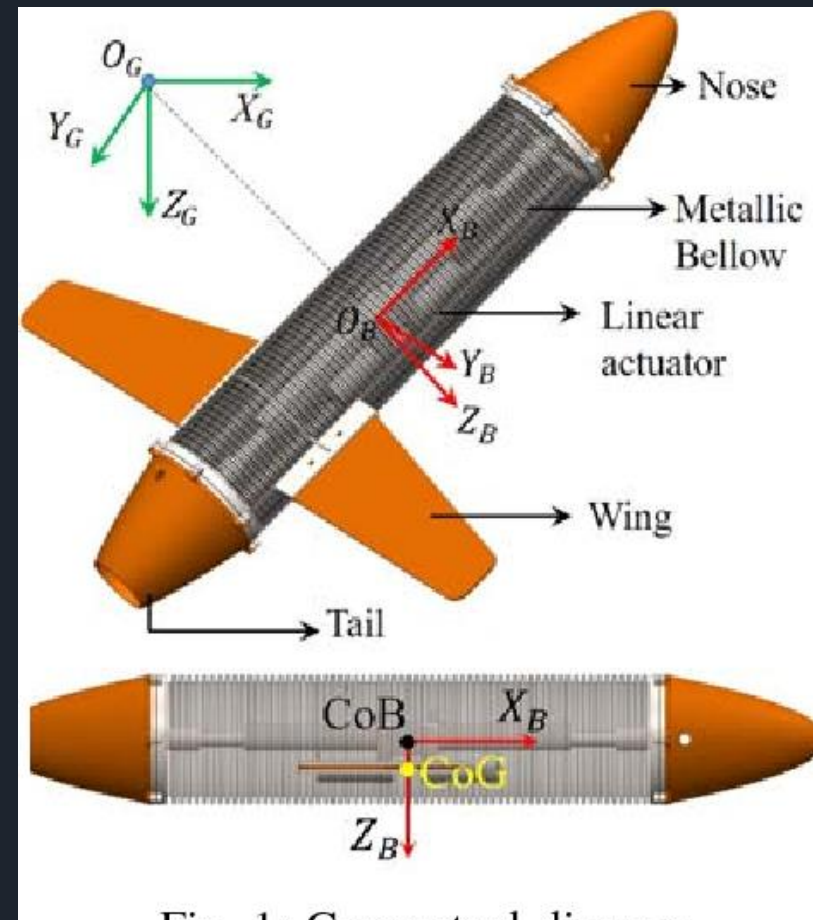


Fig. 1. Conceptual diagram

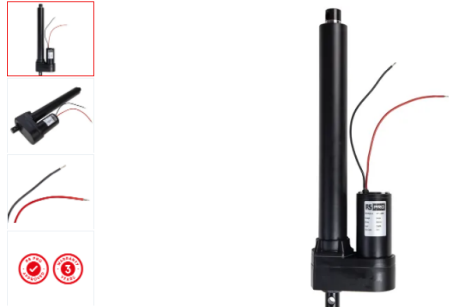
# 4) Swimming

## b) Underwater glider robot

- Actuators
- Linear actuator is one of the vital parts of this glider which actuates the bellow. In order to maintain symmetry in the design, two similar electric linear actuators with ball screw mechanism

RS PRO Miniature Electric Linear Actuator -, 24V dc, 2500N, 305mm

RS Stock No.: 177-4505 | Manufacturer: RS PRO



3 In Global stock for delivery within 4 - 6 working days

1 units [Add to basket](#)

[Real time qty checker](#)

Price Each  
MYR2,443.98

units	Per Unit
1 +	MYR2,443.98

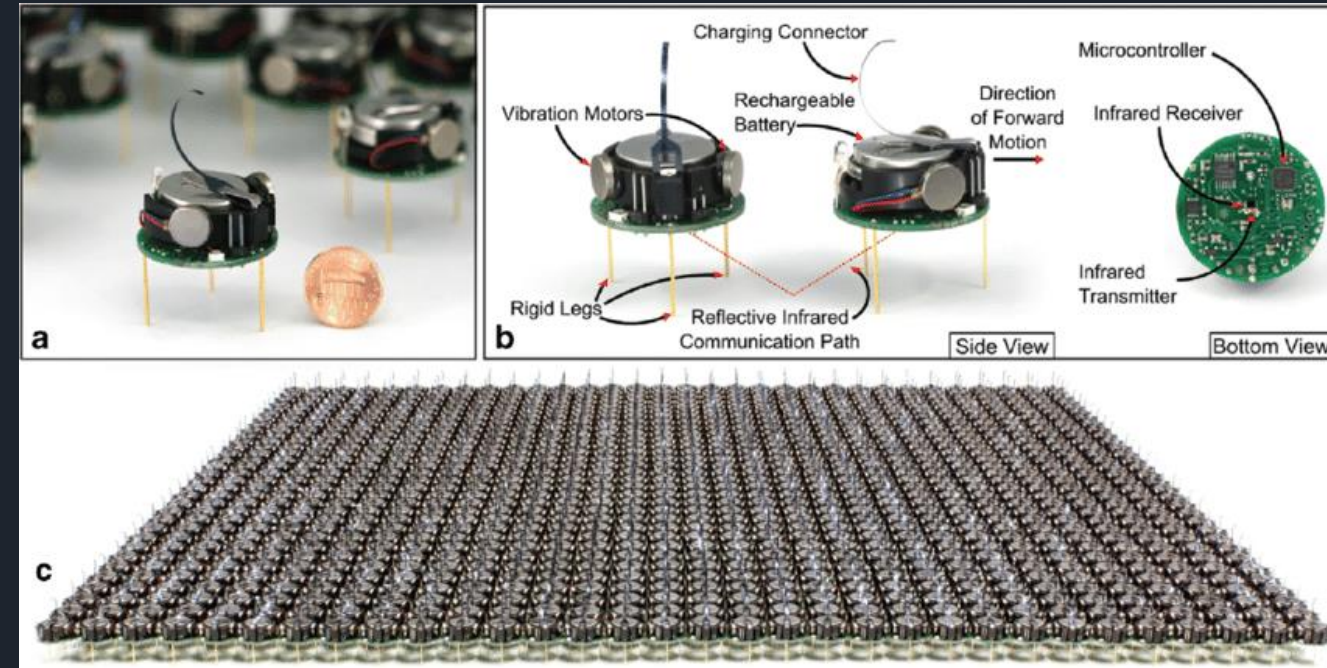
- ◆ ID10 features its heavy load capability and high speed design, which is suitable for various industrial applications requiring rapid movement.
- ◆ Input voltage : 24V DC
- ◆ Max. rated load : 7,000N (Ball screw)
- ◆ Max. static load : 13,600N (Ball screw)
- ◆ Max. current : 13.2A @ 24V DC
- ◆ Max. speed : 67.1 mm/sec @ no load
- ◆ Stroke : 102~610 mm
- ◆ Duty cycle : 25%, max 2 min continuous operation in 8 min.
- ◆ IP protection level : IP54
- ◆ Colour : Black
- ◆ Certified : CE marking, EMC Directive 2014/30/EU
- ◆ Overload protection by clutch
- ◆ Power wire length : 250mm (with tinned wires)
- ◆ Operating temperature : -25°C~+65°C
- ◆ Extension tube material : Stainless steel (Ball screw)



# 5) Others

## a) Kilobot

- Kilobot is a small mobile robot that can operate in groups of dozens to more than 1,000 units. The robots mimic how ants and other insects coordinate their swarm behaviors.
- Each Kilobot has 2 vibration motors, which are independently controllable, allowing for differential drive of the robot.



### Seeed Studio 316040001 Mini Vibration Motor for Multipurpose

RS Stock No.: 184-5122 | Mfr. Part No.: 316040001 | Manufacturer: Seeed Studio



303 In Global stock for delivery within 4 - 6 working days

1 units

Add to basket

Real time qty checker

Price Each

MYR5.52

units

Per Unit