Hardware: Locomotions & Mechanical Design (2-ACTUATORS)

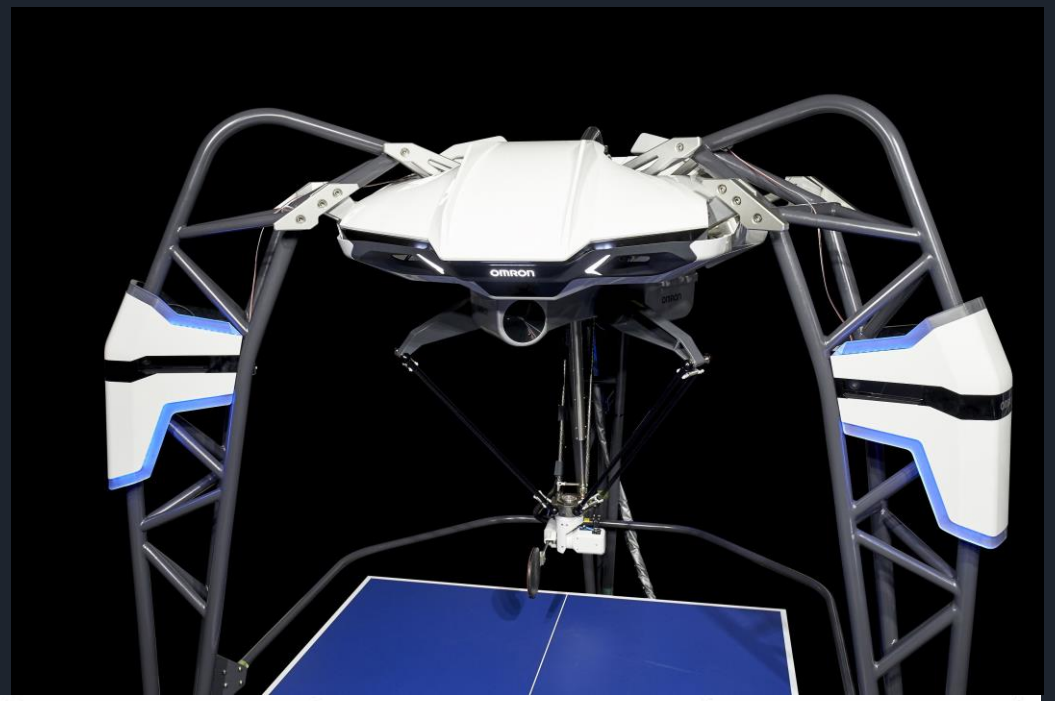
Hardware Components that move the Robots
i) Basic Motion Principle
ii)Hardware Components (Specification,Brands and Price)

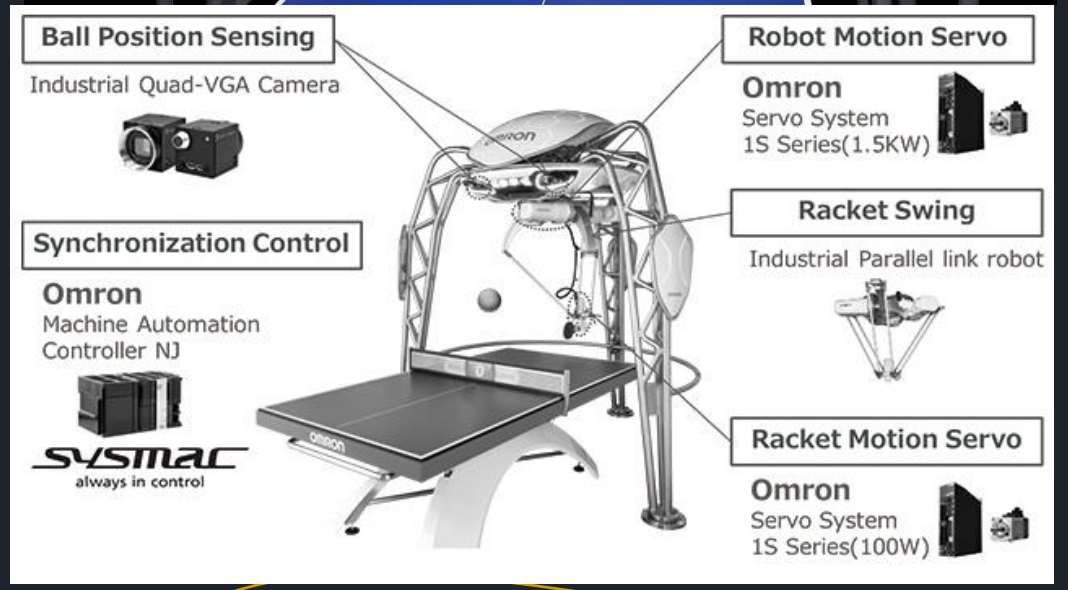
1) Stationary Robots
   a) Omron forpheus robot
2) Wheeled Robots & Tracked Robots
   a) Single wheel BB-8
   b) 4WD Omni-Directional Mobile Robot
   c) Wall Climbing Robot (Metal vs Wall vs Glass)
3) Legged
   a) Humanoid Robot (BIOLOID)
4) Swimming
   a) Fish robot
   b) Underwater glider robot
5) Others
   a) Kilobot

1) Stationary Robots
a) Omron forpheus robot

- Basic motion principle

In OMRON Forphues 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.

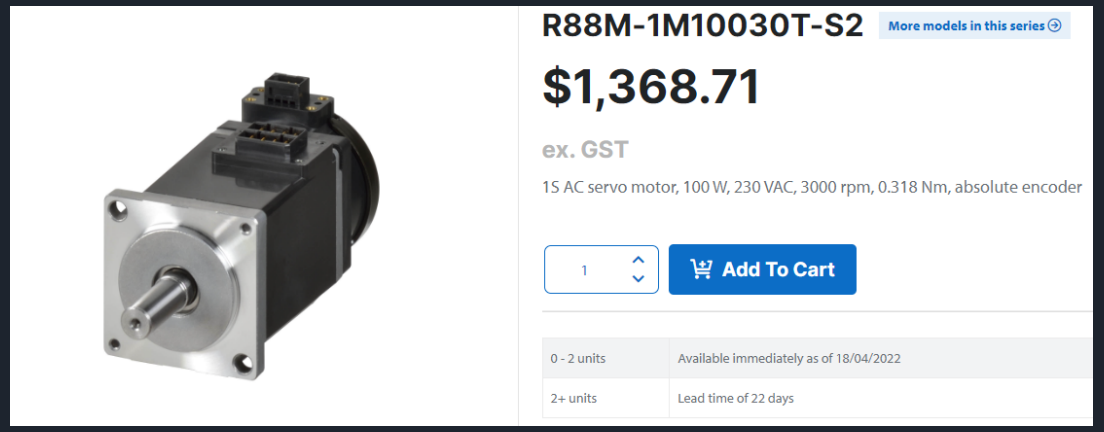




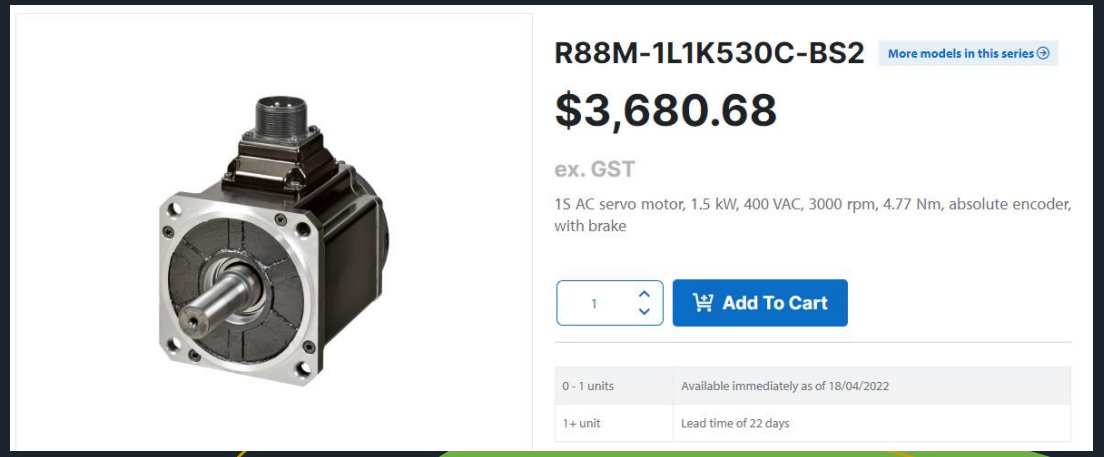
1) Stationary Robots
a) Omron forpheus robot

- 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)



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



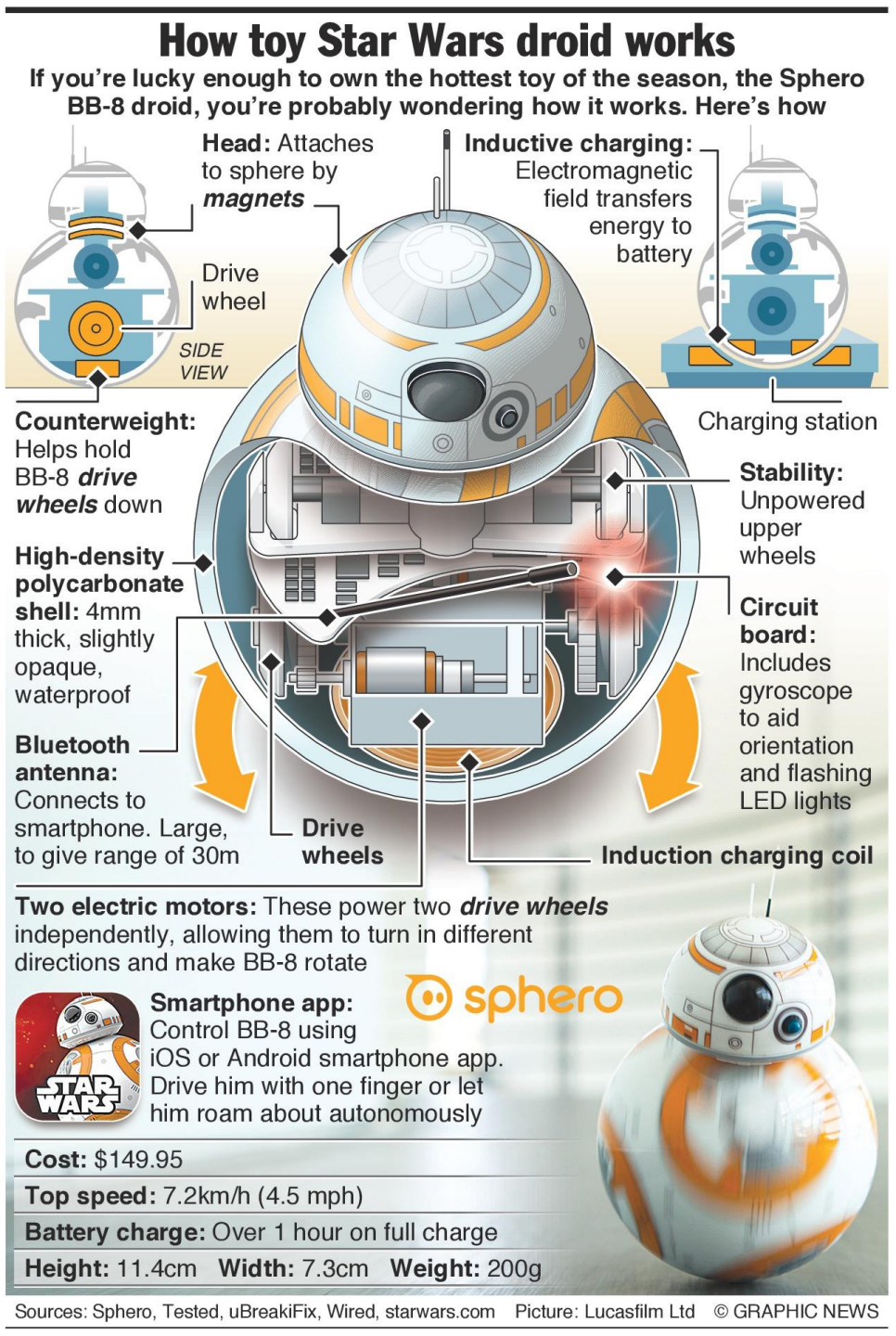
Specifications: https://store.omron.com.au/product/r8m10062m

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

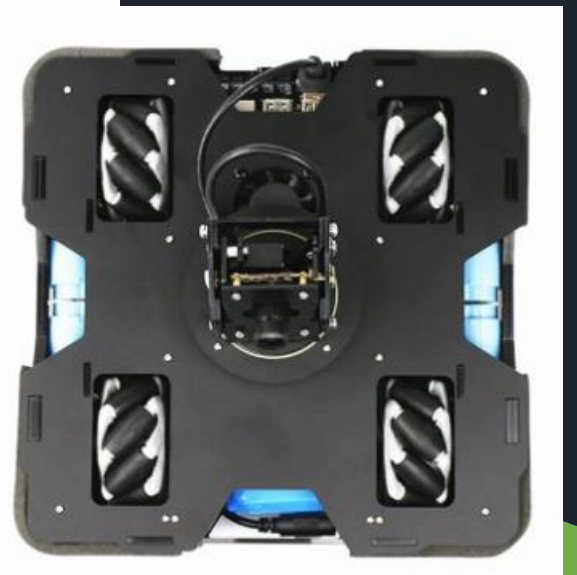
- The detailed principle can be found in the patent: https://patents.google.com/patent/US20140345957



2) Wheeled Robots & Tracked Robots
b) 4WD Omni-Directional Mobile Robot

- Working principles

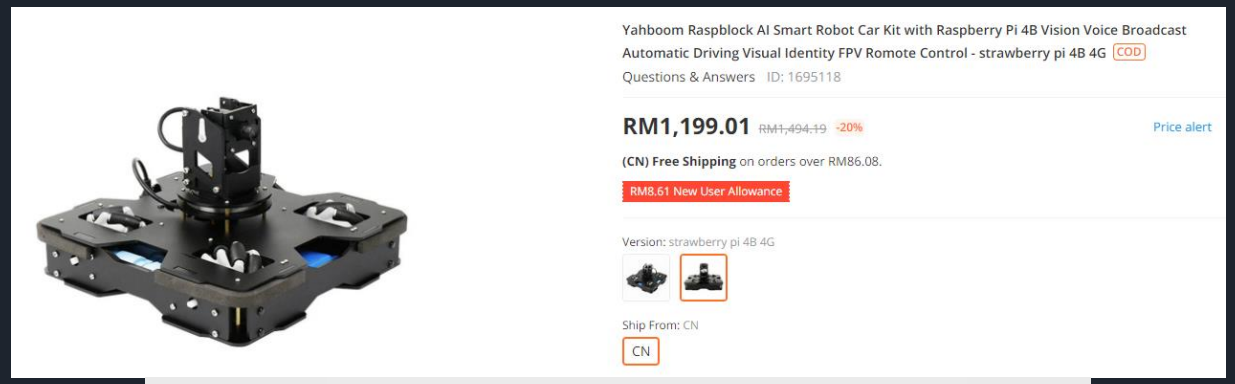
Omnidirectional robots can move in all directions without steering their wheels and it can rotate clockwise and counterclockwise with reference to their axis. They use omni-wheels which are wheels with small discs (called rollers) around the circumference which are perpendicular to the turning direction. 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.

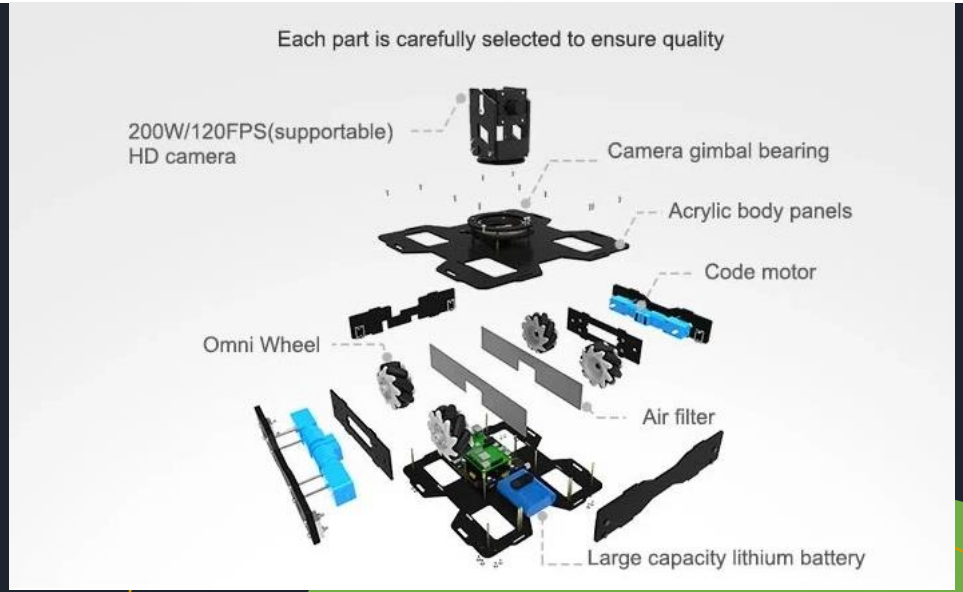


2) Wheeled Robots & Tracked Robots
b) 4WD Omni-Directional Mobile Robot

- **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





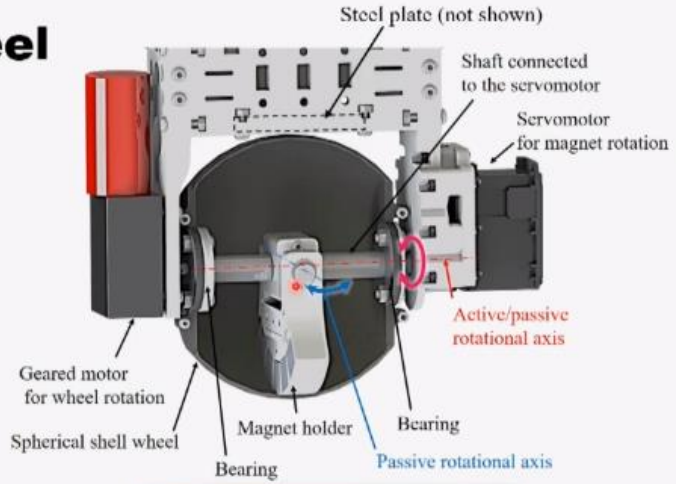
2) Wheeled Robots & Tracked Robots
c) Wall Climbing Robot (**Metal** vs Wall vs Glass)

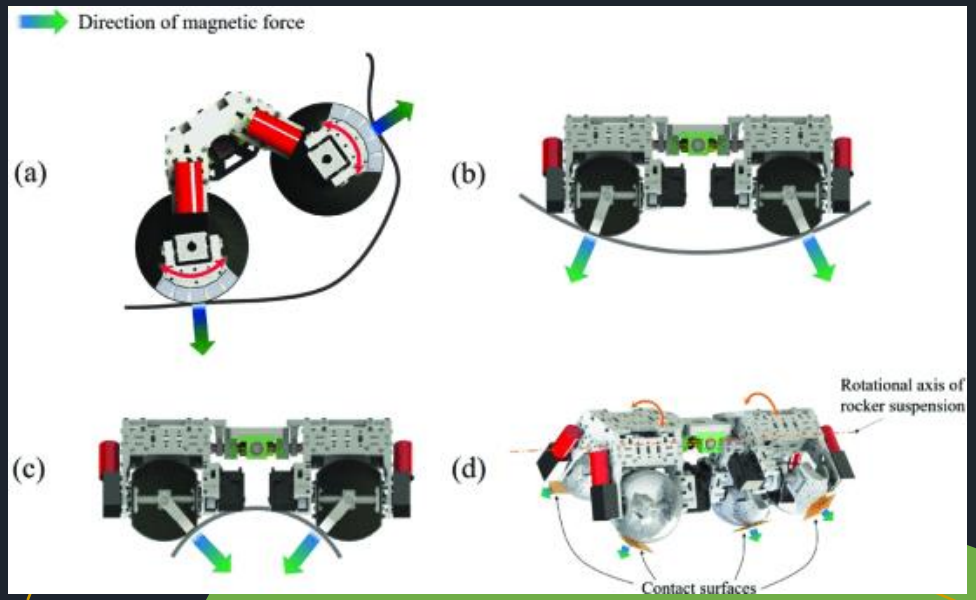
- Two main components:
  - Non-elastic suspension
  - Four spherical wheels with 2 DOF rotational magnets

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

Magnetic spherical wheel

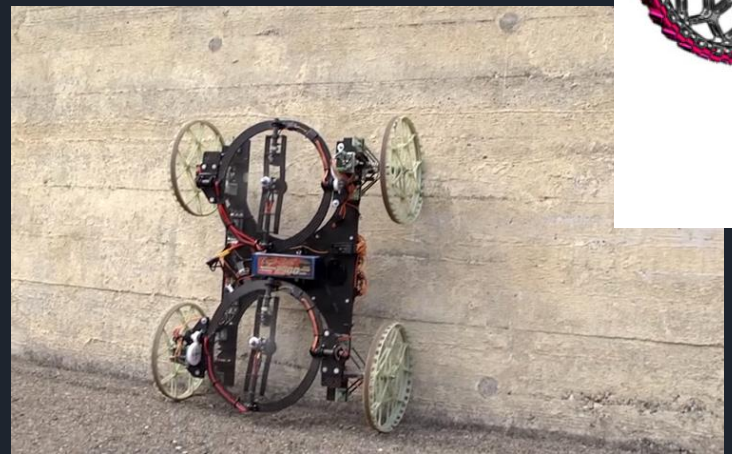
- Spherical shell wheel made of aluminum
  - directly connected to a worm gear motor shaft
  - rubber coated
- 2 DOF rotational magnets
  - Magnet holder rotation is independent of the wheel motion
  - Switchable backdrivability
    - The shaft along the red axis is directly connected to the servo motor
    - 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

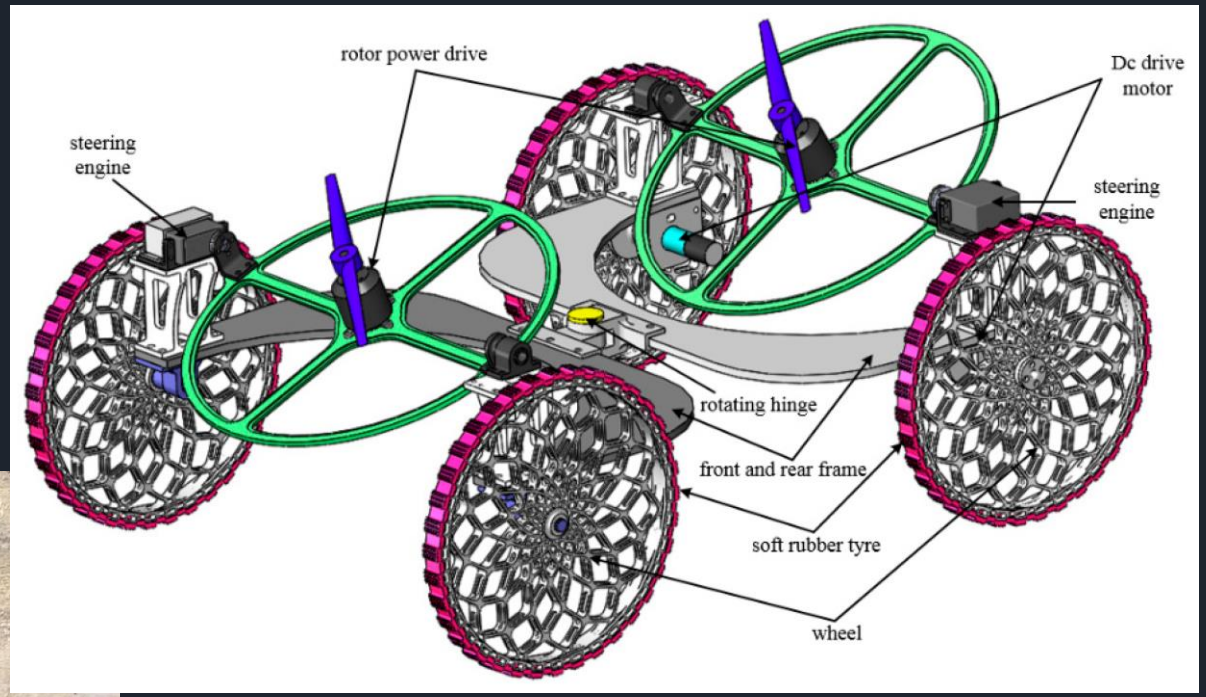




2) Wheeled Robots & Tracked Robots
c) Wall Climbing Robot (Metal vs Wall vs Glass)

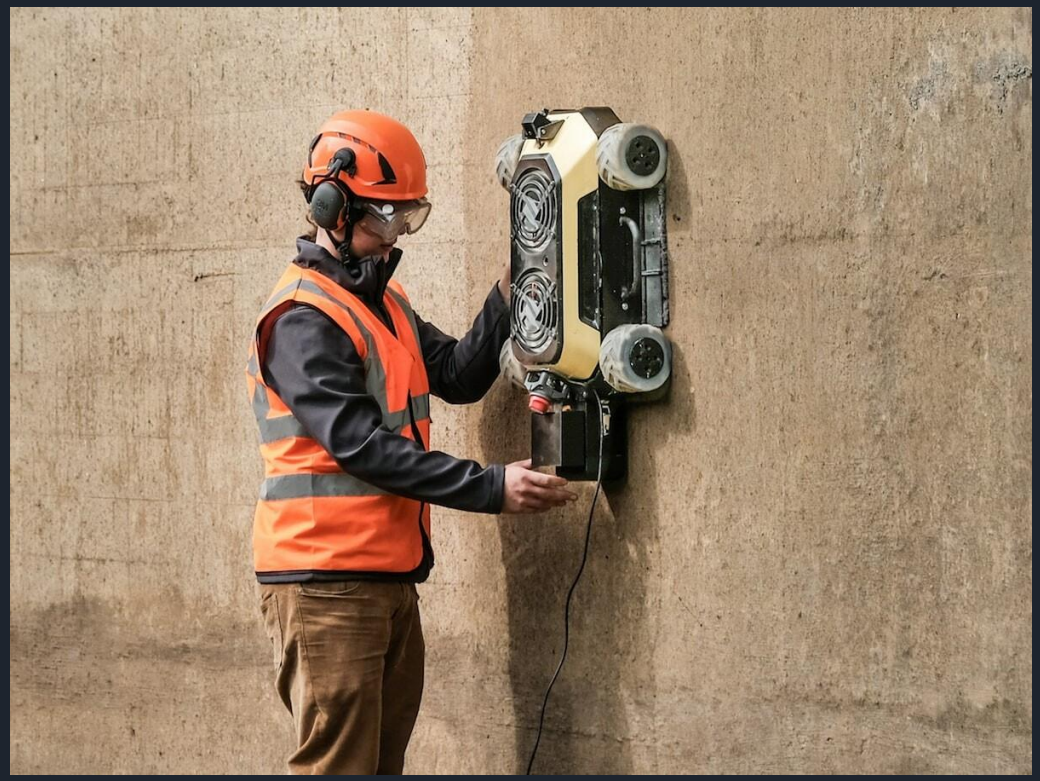
- Disney Research is developing a wall climbing robot that runs on 4 wheels.
- The robot consists of two tiltable propellers that provide the thrust.
- The pair of wheels is steerable, and each propeller has two degrees of freedom for adjusting the direction of thrust. This allows the wheels to lift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





2) Wheeled Robots & Tracked Robots
c) Wall Climbing Robot (Metal vs Wall vs Glass)

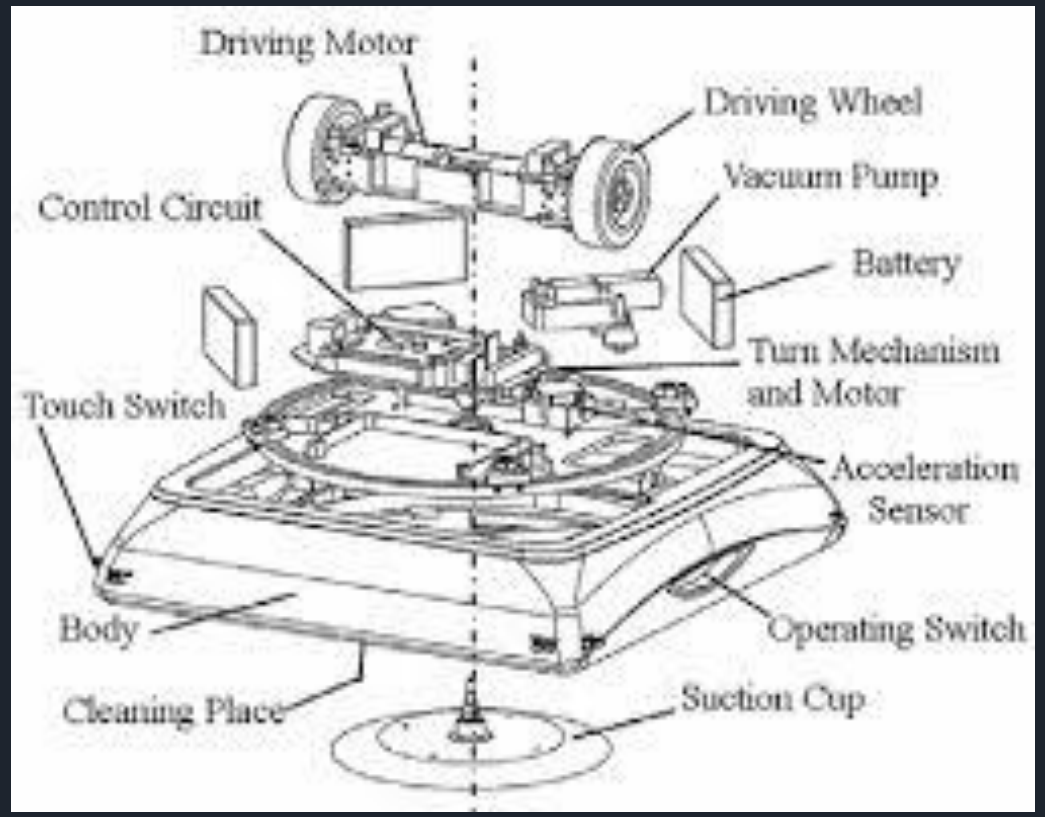
Following the same concept, HausBots wall climbing robot is utilized to perform wall inspections, painting and wall cleaning.



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.



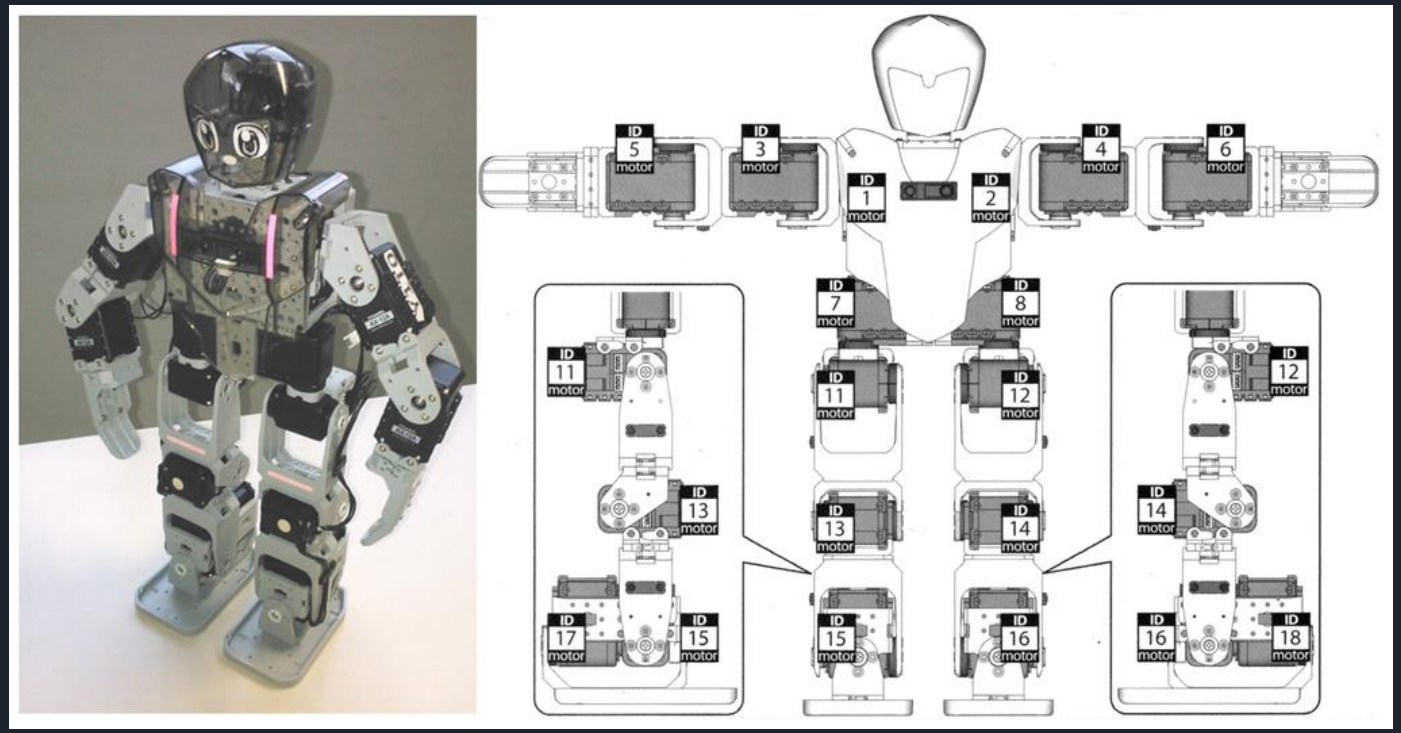
2) Wheeled Robots & Tracked Robots
c) Wall Climbing Robot (Metal vs Wall vs Glass)

- 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

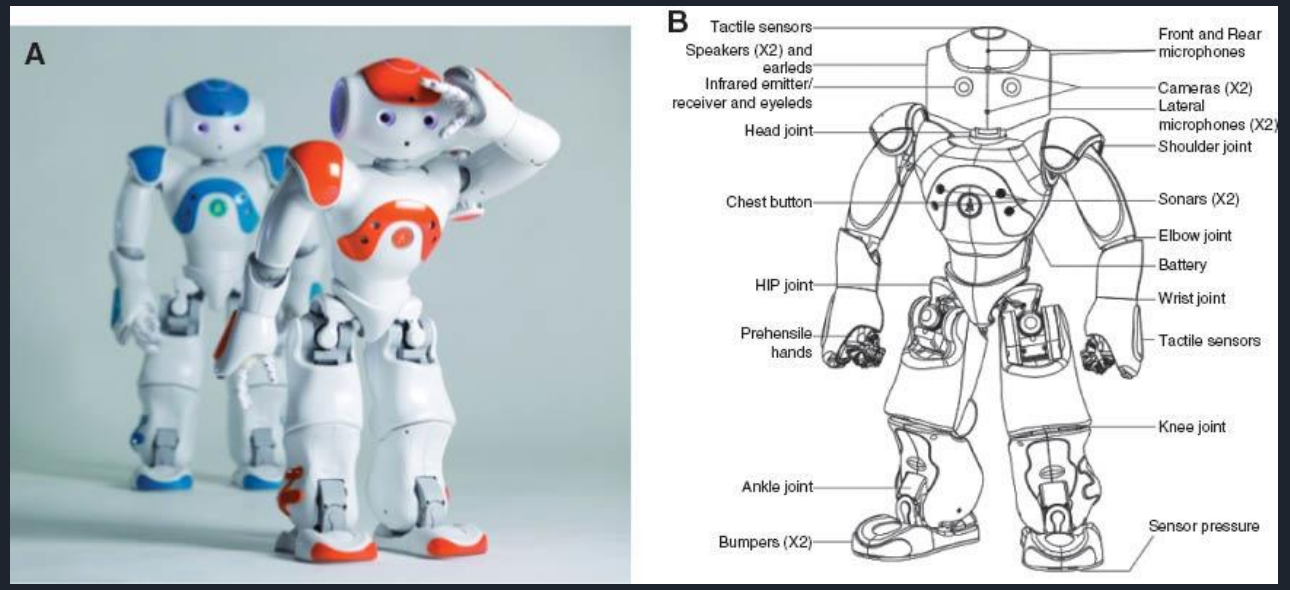
Item	Specifications
Baud Rate	7,843 [bps] ~ 1 [Mbps]
Weight	AX-12 (53.5 [g]), AX-12+ (53.5 [g]), AX-12A (54.6 [g])
Dimensions (W x H x D)	32 X 50 X 40 [mm] 1.26 X 1.97 X 1.57 [inch]
Resolution	0.29 [°]
Running Degree	0 ~ 300 [°] Endless Turn
Motor	Cored
Gear Ratio	254 : 1
Stall Torque	1.5 [N.m] (at 12 [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

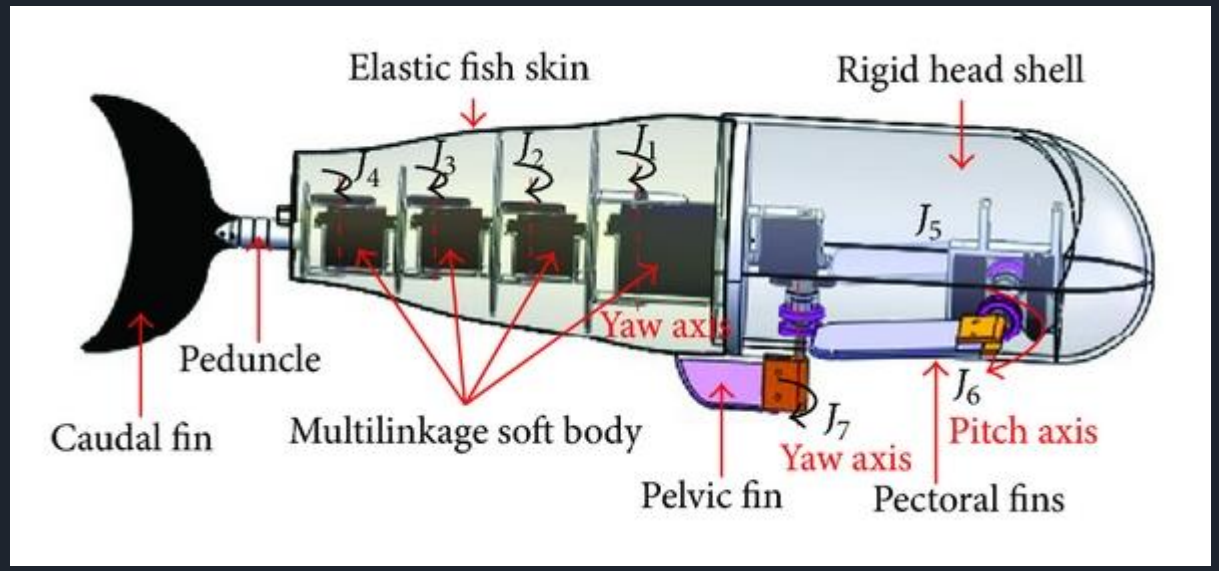
All the following methods have been applied to the humanoid robot NAO. This robot is an affordable and flexible platform. It has 25 degrees of freedom, and each motor has a magnetic rotary encoder (MRE) position sensor, which makes proprioception possible with a good precision (0.1° per MRE). Its sensing 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



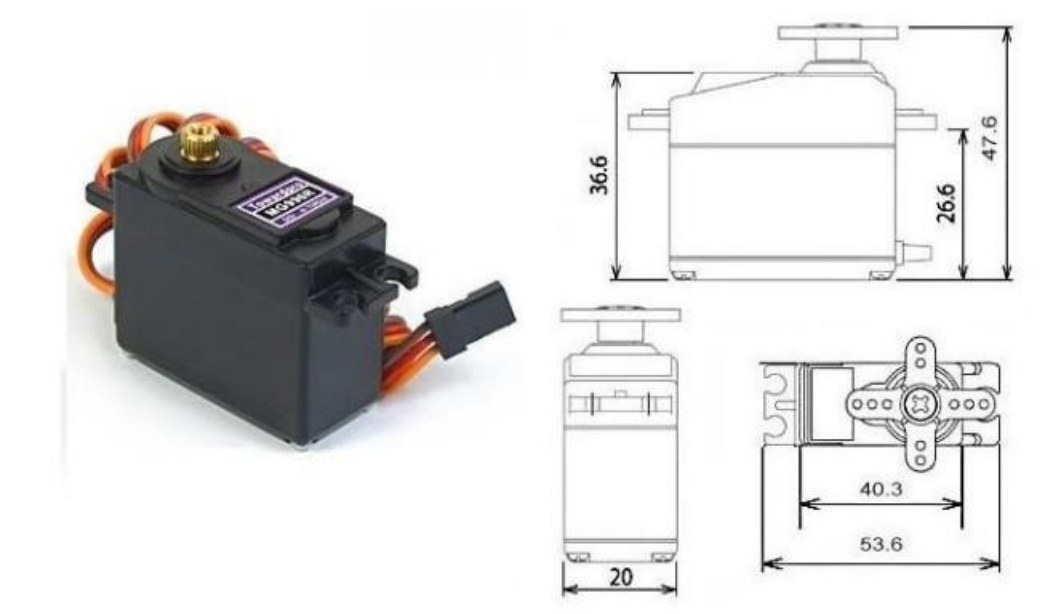
4) Swimming
a) Fish robot

- 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



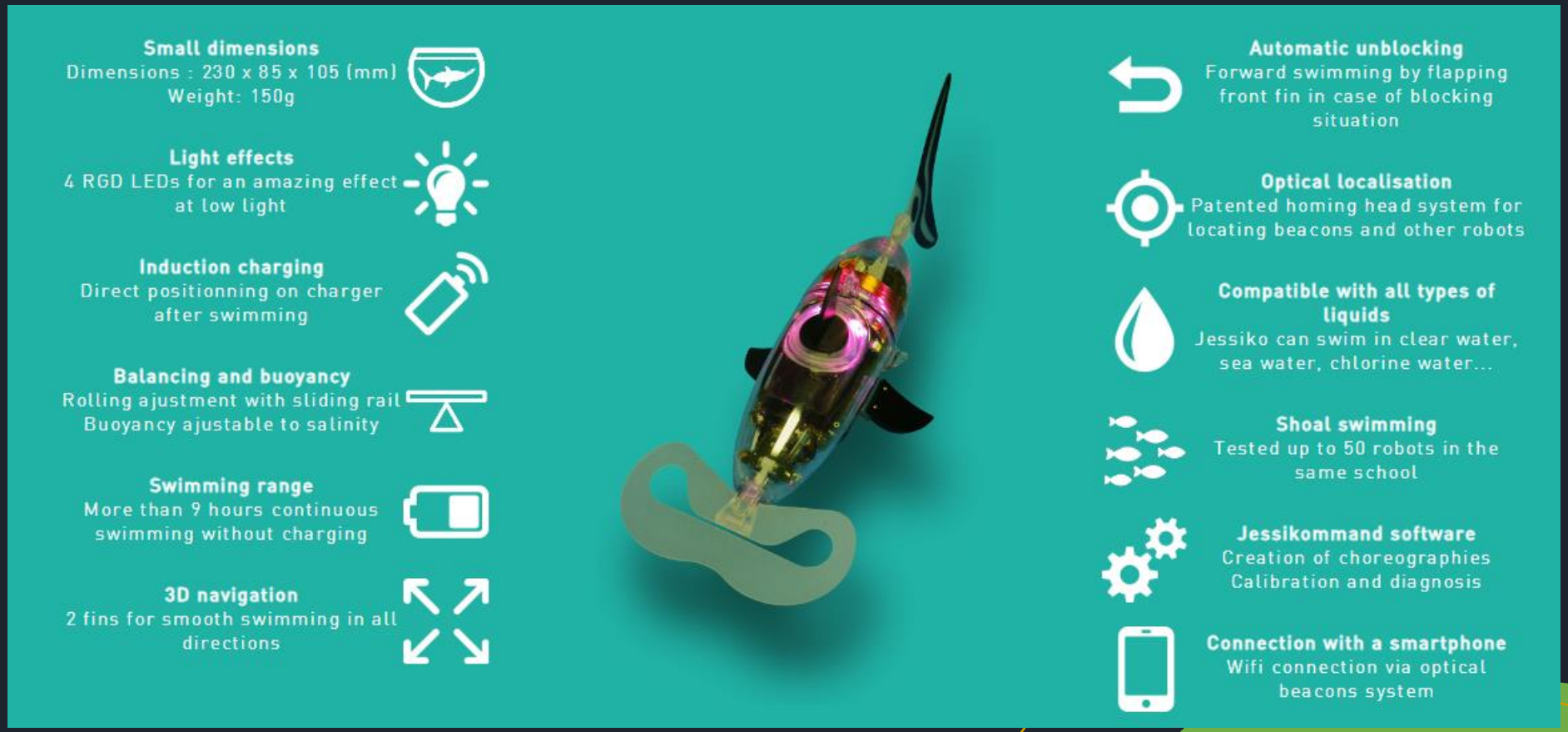
- Actuators

180-degree servomotors



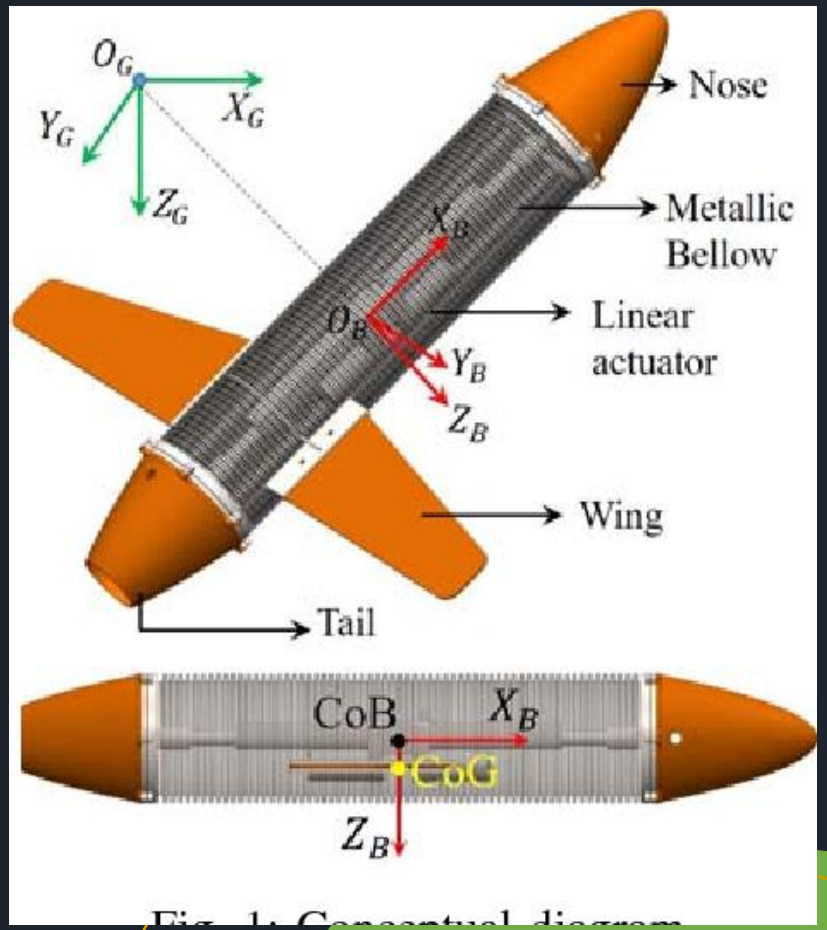
Specifications
• Weight: 55 g
• Dimension: 40.7 x 19.7 x 42.9 mm approx.
• Stall torque: 9.4 kgf·cm (4.8 V), 11 kgf·cm (6 V)
• Operating speed: 0.17 s/60° (4.8 V), 0.14 s/60° (6 V)
• Operating voltage: 4.8 V a 7.2 V
• Running Current 500 mA –
• Stall Current 2.5 A (6V)
• Dead band width: 5 µs
• Stable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

4) Swimming
a) Fish robot (Jessiko by robotswim)



4) Swimming
b) Underwater glider robot

- Working principle
- it doesn't have propellors 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.



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

- 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.