Colias Robot

Hardware: Swarm Robot

Task for 11 May 22

Kilobot: A low-cost robot with scalable operations designed for collective behaviors

History of the Robot

The term 'swarm' was first used in robotics by G. Beni and Fukuda in 1988. According to G. Beni, cellular robotics is composed of autonomous robots that operate in an n-dimensional cellular space without any central entity. Additionally, they coordinate and cooperate to accomplish common goals.

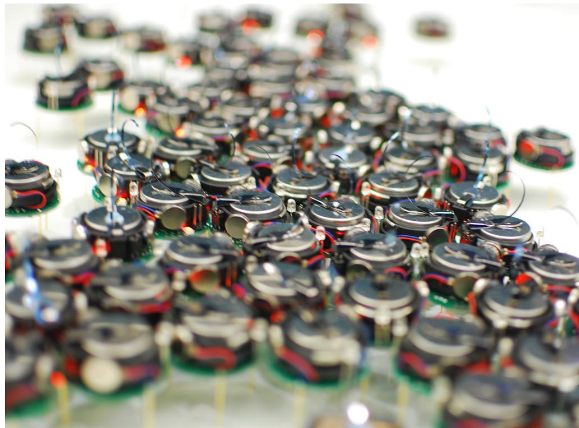
Fokuda used a swarm as a group of robots to work together like the cells of a human body. As a result, they could accomplish very complex goals. A year later, G. Beni and J. Wang introduced 'swarm intelligence,' claiming that cellular robotic systems could show intelligent behavior by coordinating their actions.

In 1993, C. Ronald Kube and Hong Zohng constructed a multi-robot system inspired by the collective behaviors of natural swarms. In the same year, Gregory Dudek defined swarm robotics based on their different features, including the size, communication range, communication topology, communication bandwidth, reorganization rate, abilities of the members, and swarm homo or heterogeneity.

Early swarm robotic systems explored swarming behaviors in species like ants, birds, fish, and others. The researchers examined these behaviors, exploring the ways how to realize these behaviors in different robotic systems. Additionally, research was driven by different inspirations, like the flocking of birds or colonies of ants.

However, in 2004, G. Beni made a fresh attempt to describe a swarm more precisely. According to him, robots in a swarm are simple, identical, and self-organizing. The system must be scalable, and only local communication is available among the swarm members. These properties are still considered the basics of defining and distinguishing swarm robotic systems from other robotic systems. According to G. Beni, the number of members in a swarm should be greater than 100 and much less than 1023.

There have been numerous other definitions for swarms. They all agree on the main idea, i.e., natural swarming and basic properties like local interactions and coordination, into real-life applications with swarms of robots. A more recent definition came in 2001. It defined a swarm as "a population of interacting individuals that optimizes a function or goal by collectively adapting to the local and/or global environment." The coordination and cooperation in a swarm are achieved via very simple rules.

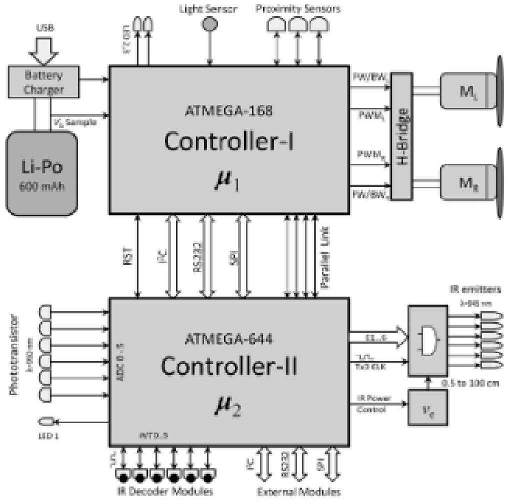


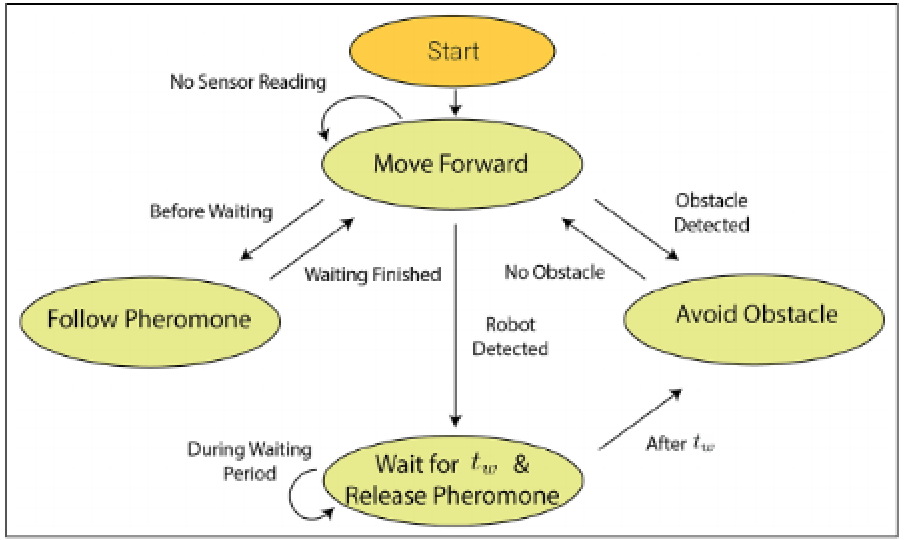
Characteristic of Swarm Robot

The key characteristics of swarm robots are as follows:

- **Autonomy:** A swarm robotic system consists of autonomous robots that can physically interact with the environment.
- **Large number:** The system consists of limited homogeneous groups of robots in which each group contains a large number of members.
- **Limited capabilities:** Each robot in the system is relatively incapable or inefficient in carrying out tasks independently, but they are highly efficient when they cooperate as a group.
- **Scalability and robustness:** A swarm robotic system is scalable and robust. Increasing the number of units will improve the overall performance.
- **Distributed coordination:** The coordination between robots is distributed. Each robot has local and limited sensing and communication abilities.

Basic System Architecture





Colias employs two on-board ATMEL AVR micro-controllers in parallel: μ_1 and μ_2 (see Figure 2). The parallel processing provides for the fast and reliable control of different functions of the robot. As shown in the robot's basic architecture in Figure 2, the functions: i) power management, ii) obstacle detection and iii) motion control are managed by μ_1. Moreover, μ_2 controls the inter-robot communication and the user-programmed scenarios (individual and social tasks). The priority of the processors is programmable, although by default the high priority tasks are performed by μ_1.

Inter-processor communication is an important issue which affects the speed of processing and its reliability. Therefore, the robot employs two different links between its processors – parallel and serial. In the parallel link, both processors can be defined as a master or as a slave. With serial communication, the robot has three different links, namely, RS-232[1], I^2C[2] and the SPI[3]. In general, all three serial links (buses) can be used to establish a connection between the processors. Moreover, these links are used to communicate with the external modules, such as the camera, the external memory and the robot-PC link. We also used the SPI bus to program the micro-controllers.

0	History of the robot	Ancient History, Muslim & Western Theory History, World War, Space Exploration, Digital Edge and IR4.0, Future Applications
	COMPLETE SYSTEM ARCHITECTURE	**System Connectivity, Wiring Diagram (Power/Data)**
	ROBOTICS HARDWARE COMPONENTS	
1	Robot Body Design vs Tasks	Body shapes and materials use for different application (Underwater, Ground, Air, Space). Regulation, Certification and Compliant Needed?
2	Actuators/Locomotions	Types of actuator. To move the main body of the robot (Tires, motors, rotor, drivers n etc). Add on accesories to the robot (Manipulator, End Effector, Custom/Specific task, Servo, Dyanmixal Servo, DC/AC Motor, Hydraulics, Pneumatic, Linear actuator etc). Bearing, Sliders, Gears, Pulley System, Slip Ring, Linear etc)
3	Navigation System & Controller	Types of sensors/controller for perception and navigation. (Types of Computer (Edge AI, Industrial PC, PC104, DAQ, Controller) Sensor (LIDAR, Camera IR/Color/Thermal, Depth Camera, Radar, Ultrasonic, Laser, Bumper Sensor, Magnetic Guide, IMU, Encoder etc)
4	Data Collection	Types of Instruments for data collections. (Remote Sensing, Mapping, Surveillance, etc)
5	Data Transmission	Types of communication devices and protocols. Cables (Digital vs Analog, RS232/485/422, BUS, CAN, HARP, I2C, ISP, Ethernet, OPTIC etc) vs Wireless (IR, Bluetooth, WIFI, BLE, RF, Satellite, Telco 4G/5G, GPRS & etc)
6	Power System Management	Types of power supply. AC, DC cables. Batteries. Engin. Renewable Energy.

1) Robot Design

In this section, we explain the designed hardware and control mechanism of Colias with regard to individual and social behaviours. Figure 1 shows a Colias robot and its different modules. The robot has two boards – upper and lower – which have different functions. The upper board is for high-level tasks, such as inter-robot communication and user-programmed scenarios; however, the lower board is designed for low-level functions such as power management and motion control.

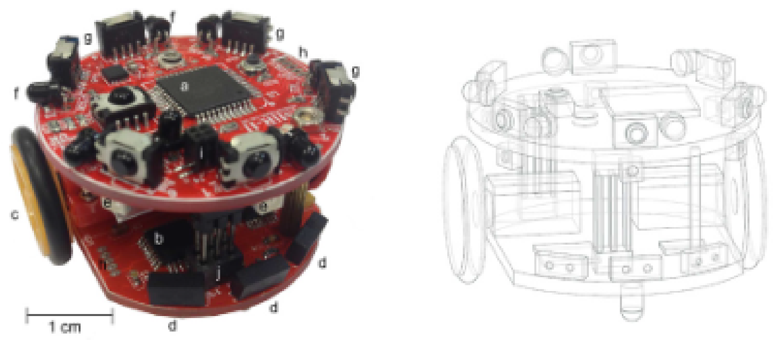


Figure 1. (Left) Colias mobile robot. a: Upper board processor, b: 2^{nd} processor for motion and power management, c: 2.2 cm diameter wheels, d: proximity (bump) sensors, e: IR transmitters, f: IR phototransistors, g: IR decoders, h: SPI port, i: RS-232, j: I^2C and parallel links. (Right) A 3D simulated robot to be used in simulation software.

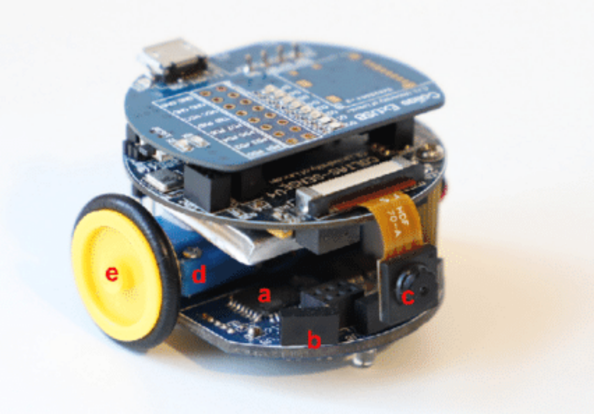
Specifications

- Upper board processor
- Second processor for motion and power management
- 2.2 cm diameter wheels
- Proximity sensors
- IR transmitters
- IR decoders

2) Actuators / Locomotions

Two micro DC motors employing direct gears and two wheels with a diameter of 2.2 cm actuate Colias with a maximum speed of 35 cm/s. The rotational speed for each motor is controlled individually using a pulse-width modulation (PWM) technique. Each motor is driven separately by a H-bridge DC motor driver and consumes average power of 35 ± 5 mA in no-load conditions and up to 150 ± 20 mA in stall conditions. The robot uses the differential-driven configuration, which is a simple method to control a mobile robot using a very basic motion control principle. Since the motors are directly supplied by the battery of the robot, any changes in battery level will impact the speed of the robot.

As the employed motors' gearbox ratio is high (120:1) and the robot is lightweight (28 g), the robot does not need much torque ($\tau m \cong 0 \tau m \cong 0$) to move. As a result, the acceleration of the motors is similar to the no-load condition and this causes the speed to settle within a few milliseconds.



2pcs High Elastic Rubber Wheel Tires

4.9 ★★★★★ | 22 Ratings | 65 Sol

RM1.80 - RM4.20

2.25 "- diameter: 56MM, thick 20MM, the hole: 3.1MM, weight 8.0 grams

3) Navigation System & Controller

The basic configuration of Colias uses only IR proximity sensors to avoid obstacles as well as collisions with other robots, and a light sensor to read the illuminance of the ambient light. The IR sensory system consists of two different types of IR module, namely, short-range sensors and long-range sensors. A combination of three short-range sensors and an independent processor grants the capacity for an individual process for obstacle detection which works in parallel with the rest of the system. A similar, although complex, mechanism has been found in locust vision, in which a specific neuron called the 'lobula giant movement detector' (LGMD) which reacts to objects approaching the insect's eyes.

The long-range system is composed of six IR proximity sensors (each 60 ◦◦ on the robot's upper board) for obstacle and robot detection. The IR sensing system is able to distinguish robots from obstacles. The range of the system is approximately 15 ± 1 cm with a radiant power of 6 mW/sr (adjustable up to 15 mW/sr).

Short Range

FEATURES

- Package type: surface-mount
- Dimensions (L x W x H in mm): 8.0 x 3.0 x 1.8
- Integrated modules: infrared emitter (IRED), ambient light sensor (ALS), proximity sensor (PS), and signal conditioning IC
- Operates ALS and PS in parallel structure
- Filtron™ technology adoption for robust background light cancellation
- Supports low transmittance (dark) lens design
- Temperature compensation: -40 °C to +85 °C
- Low power consumption I²C (SMBus compatible) interface
- Floor life: 168 h, MSL 3, according to J-STD-020
- Output type: I²C bus (ALS / PS)
- Operation voltage: 2.5 V to 3.6 V
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Integrated Proximity Sensor, 2.5V to 3.6V Supply, SMD-10

3) Navigation System & Controller

Long Range

Infrared Phototransistor

Lite-On No. LTR-3208E

In stock

$0.70

Add to Cart

Quantity discounts:
10+ units: $0.47 each
50+ units: $0.44 each
100+ units: $0.40 each
500+ units: $0.37 each
33 each

Specifications

- Peak wavelength: 940 nm
- Package: Round 5 mm (T-1 3/4)
- Lens type: dark plastic to cut visible light
- Viewing angle: 20 degrees
- Voltage - Collector Emitter Breakdown (Max): 30 V
- Current - Collector (Ic) (Max): 3.12 mA
- Current - Dark (Id) (Max): 100 nA
- Power - Max: 100 mW
- Lead-free (RoHS compliant)
- Manufacturer: Lite-On Electronics, Inc.
- Manufacturer part number: LTR-3208E
- Datasheet (PDF)

Infrared Transmitter LED 3mm

★★★★★ 88 Ratings
Brand: China

RM0.80
20 or more RM0.70
100 or more RM0.64
Cashback: 3%
CytronCash Balance: Login

Availability: 1112

1

ADD TO CART

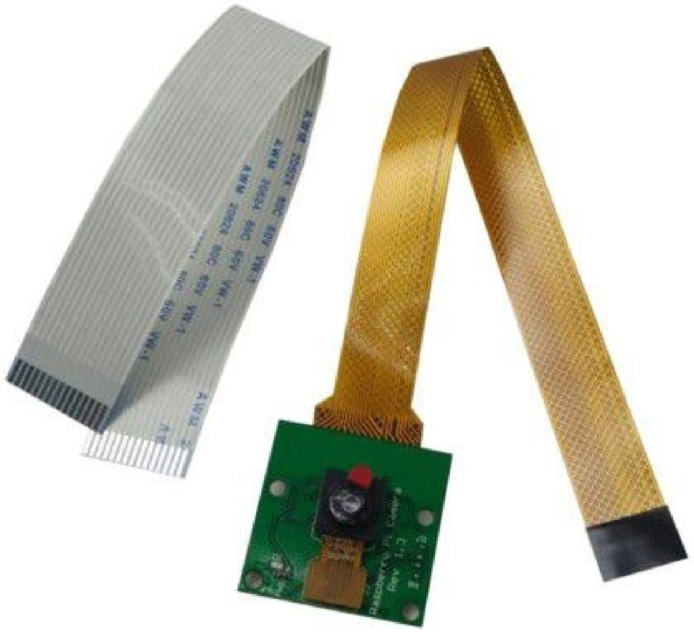
Product Code: SN-IR-T3
Warranty Period: 12 months

Add to Wish List   Share

Features:

- Infrared Transmitter/Emitter
- 3mm in diameter
- Wavelength: 940nm
- Anode: Long pin (small flag)
- Cathode: Short pin (big flag)

4) Data Collection



5MP Camera Board for Raspberry Pi

★★★★★ 338 Ratings

Brand: China

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RM40.00

10 or more RM38.40

30 or more RM36.00

Cashback: RM1.20

CytronCash Balance: Login

The board itself is tiny, at around 25mm x 20mm x 9mm. It also weighs just over 3grams, making it perfect for mobile or other applications where size and weight are important. The camera is connected to the BCM2835 processor on the Pi via the CSI bus. This bus travels along the cable(FFC - Flexible Flat Cable) that attaches the camera board to the Pi. Yes, we know Raspberry Pi Zero and Zero W has different CSI connector, this camera comes with 2 different FFC cables, one for standard Raspberry Pi(Model A, B and B+) and the compact Raspberry Pi (The Zero series).

The sensor itself has a native resolution of 5 megapixels and has a fixed focus lens onboard. In terms of still images, the camera is capable of 2592 x 1944 pixel static images, and also supports 1080p @ 30fps, 720p @ 60fps and 640x480p 60/90 video.

5) Data Transmission

In multi-robot experiments, the robots need to utilize a communication media in order to share their information and make collective decisions. Wireless communication is generally used when a scenario is to be accomplished with mobile robots. In this regard, infrared is a suitable choice as an inter-robot communication medium for robotic swarm applications compared with other wireless communication techniques, such as radio frequency. The advantages of using IR in swarm applications include position estimation, neighbouring robot recognition and direct communication, and they can be utilized for obstacle avoidance [25].

Infrared Emitter, High Power, 940 nm, 10 °, T-1 3/4 (5mm), 15 mW/Sr, 800 ns, 800 ns

FEATURES

- Package type: leaded
- Package form: T-1¾
- Dimensions (in mm): Ø 5
- Peak wavelength: λ_p = 940 nm
- High reliability
- High radiant power
- High radiant intensity
- Angle of half intensity: $\varphi = \pm 10°$
- Low forward voltage
- Suitable for high pulse current operation
- Good spectral matching with Si photodetectors
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

6) Power System Management

In swarm robot scenarios, the robot must have sufficient battery power to complete a given task. To achieve long-term autonomy, we need to have a proper power management system to monitor all the functions of the robot during a task and to control the battery charging current during a recharging process such that it increases the battery life. In Colias, the lower board is responsible for managing power consumption as well as the recharging process. The power consumption of the robot with normal motion (in a quiet arena with only walls) and short-range communication (low-power IR emitter) is around 560 mA. However, it can be reduced to about 200 mA when the emitters are turned on only occasionally and the robot moves at a faster speed. A 3.7 V, 600 mAh (extendible up to 1200 mAh) lithium-polymer battery is used as the main power source, which gives autonomy of around three hours for the robot. More battery power is used by IR emitters and decoders when the emitter is turned on continuously. Therefore, the power consumption can be reduced to at least 50% by using pulse modulation in the IR emitters as well as a short data-packet size.

The recharging process of the battery is monitored by an external constant current/constant voltage linear charger IC (LTC4054-4.2). We fixed the charging current to a maximum of 400 mA in order to be able to use USB power to charge the battery.

Moreover, in-scenario recharging techniques, such as a docking charger [28–30] or movable chargers [31], can be applied to increase the autonomy time in long-term scenarios.

Preferred 3.7V lithium polymer battery 602535 582535 500mAh 600mAh MP3 MP4 GPS Bluetooth

5.0 ★★★★★ | 123 Ratings | 242 Sold

RM10.30

100% Authentic Guarantee

Guarantee Authentic or Money Back

Size is 6mm (±0.2MM (Thick) x 25mm (Width) x 35mm (Long)

Important: Make sure the size of battery is suitable for your device.

Specifications:

Rated voltage: 3.7V

Charging voltage: 4.2V

With rich crystal protection board