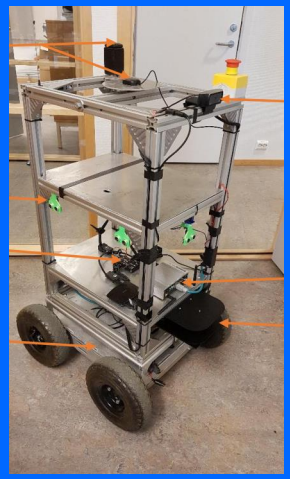
Autonomous Mobile Greenhouse Robot

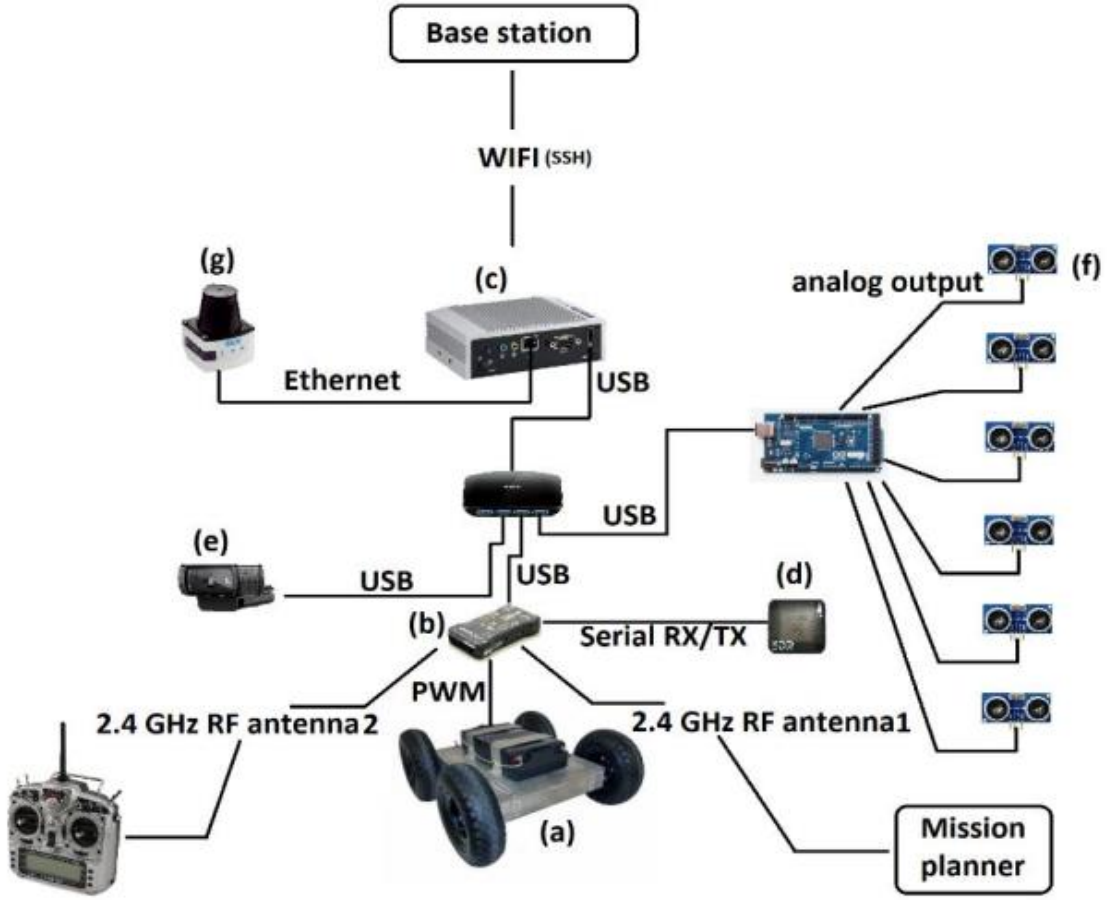
Harik, E. H. C., & Korsaeth, A. (2018). Combining hector SLAM and artificial potential field for autonomous navigation inside a greenhouse. *Robotics*, *7*(2). https://doi.org/10.3390/robotics7020022

Introduction

- An autonomous mobile ground robot used for fertilization, monitoring physical growth conditions, disease detection, and crop harvesting in modern greenhouse.
- Has an ability to navigate safely in indoor environment with an active obstacle detection system.
- Navigate in small and tight conditions



Hardware Architecture



Body Design & Materials

AUTONOMOUS MOBILE GREENHOUSE ROBOT

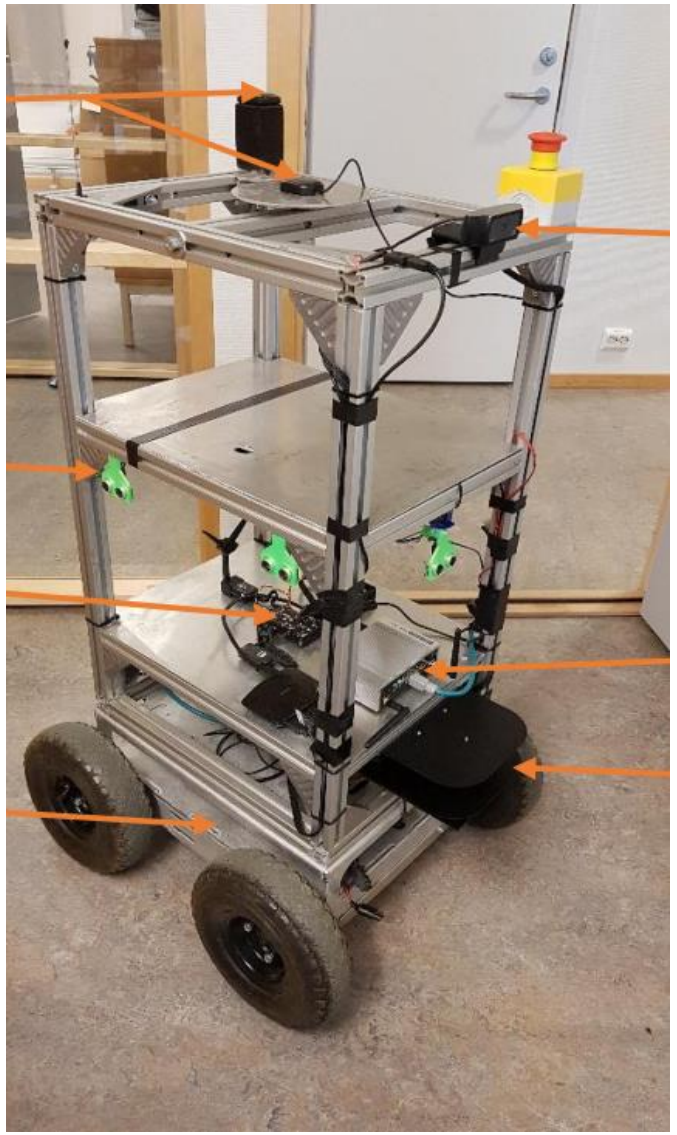
Body Design

Design Advantages

- Ability to move in small and tight path.
- Good traction and stability in uneven terrain.

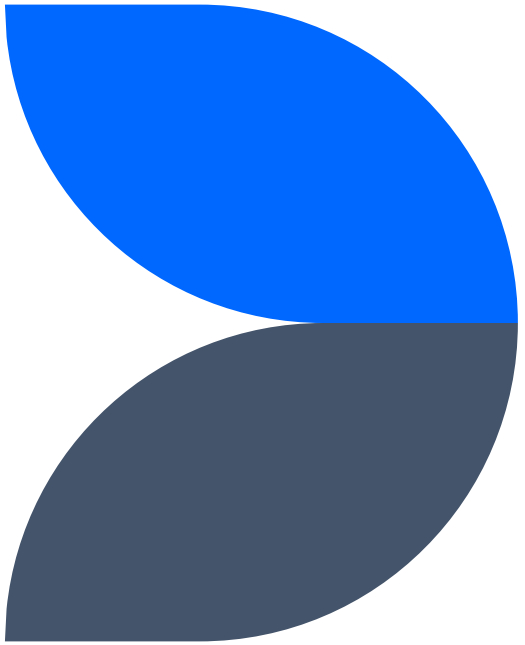
Material

- Aluminium Extrusion Connected with L- Joints
- Rubber Pneumatic Tyre



Locomotion

AUTONOMOUS MOBILE GREENHOUSE ROBOT



Locomotion

IG52 – DB4

10-inch Pneumatic Wheels

IG52 – DB4

Specifications

Dimensions (LxWxH): 25.5" x 22.0" x 10.5"

Weight: 31.8 kg

Drive Method: Direct Drive

Payload range: 9 to 72.5 kg

Top Speed: 5.8 km/h

Gear Motors: Four (4) IG52 285 RPM Gear Motors (one per axle/wheel).

Wheels: Two (2) pair of 10-inch pneumatic wheels.

Battery System: Two (2) Interstate 12V 18 Ah Lead Acid Battery providing 1-3 hours of operation depending on use.

Motor Controller(s): One (1) Sabertooth Dual 12A Motor Driver.

Steering Method: Differential Steering (Varying Motor Speed)

PNEUMATIC TYRE

Advantages

- Ability to absorb the unevenness of terrain by providing smoother ride, and less bumping and shaking.
- Thicker thread provide good traction.
- Higher durability than cushion tyre.

3.
Navigation System & Controller

Controller

ARK-1123H Embedded Computer

Processor	
CPU	Intel Celeron Processor J1900 Quad Core 2.0 GHz SoC
Core Number	4
Frequency	2.0 GHz (Up to 2.41 GHz w/ burst frequency enabled)
L2 Cache	2 MB
BIOS	AMI EFI 64 Mbit (Default BIOS is supported for 64-bit OS installation, BIOS for 32-bit OS is supported by project)
Memory	
Technology	DDR3L 1333 MHz
Max. Capacity	8GB
Socket	1 x 204-pin SO-DIMM
Graphics	
Chipset	Intel® Atom SoC integrated
Graphic Engine	DirectX* 11.1, OGL 3.0, OCL 1.1, OGL ES 2.0 Encode: H264, MPEG2/4, VC1, WMV9 Decode: H264, MPEG2
HDMI	2 x Lockable HDMI connector, support up to 1920 x 1080 at 60Hz (2nd HDMI w/o audio function by Intel limitation)

Audio	
Main System	ALC-888S, High Definition Audio. Line-out & Line-in
Ethernet	
LAN1	10/100/1000 Mbps Intel i210 GbE, support Wake On Lan
LAN2	10/100/1000 Mbps Intel I210 GbE, support Wake on LAN
I/O Interface	
Serial Port	1 x RS-232/422/485 (BIOS selectable)
USB Interface	2 x USB 2.0 & 1 x USB3.0
Other	
Watchdog Timer	255 levels timer interval, setup by software
Expansion	
Mini PCIe	1 x Full-size Mini PCIe, support WLAN or WWAN module
Storage	
2.5" Drive Bay	1 x 2.5" SATA HDD Bay (Max Height 9.5mm)
mSATA	1 x Half-size mPCIe (Suggest to assembly by CTOS or T-Part due to complex installation)
Software Support	
Microsoft Windows	WES7, Windows 7, WE8S, Windows 8 and Windows 10 (32-bit support by project)
Linux	Support (by Project)
Power	
Input Voltage	12 VDC
Power Adaptor	AC to DC, DC12 V/3 A, 36 W with threaded design
Consumption	Typical 5.64 W, Max. 14.04 W

Does all the computational work from all the peripherals

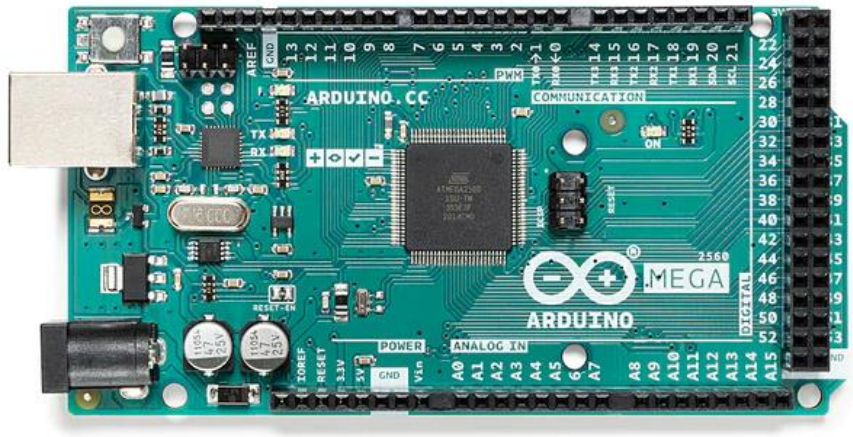
Mechanical	
Construction	Aluminum housing
Mounting	VESA/DIN Rail/Wall Mounting Kits (Optional)
Dimensions	133.8 x 43.1 x 94.2 mm (5.27" x 1.7" x 3.71")
Weight	0.8kg
Environment	
Operating Temperature	With extended temperature SSD/mSATA/RAM : -20 ~ 60° C with 0.7m/s air flow With standard temperature HDD/SSD/mSATA/RAM peripherals:0 ~ 40° C with 0.7m/s air flow
Storage Temperature	-40 ~ 85° C (-40 ~ 185° F)
Relative Humidity	95% @ 40° C (non-condensing)
Vibration during Operation	With mSATA/SSD: 3 Grms, IEC 60068-2-64, random, 5 ~ 500 Hz, 1 hr/axis With HDD: 0.5Grms, IEC 60068-2-64, random, 5~500Hz, 3 axes, 1hr/axis
Shock During Operation	With mSATA/SSD: 30 G, IEC 60068-2-27, half sine, 11 ms duration With HDD: 10G, IEC 60068-2-27, half sine, 11 ms duration
Certification	
EMC	CE/FCC Class B, CCC, BSMI
Safety Certifications	UL 62368, CB 62368, CCC, BSMI

Pixhawk PX4

Mission Planner software
Manual control
Control PWM for motors

Dimensions	84mm x44mm x12mm
Weight	G.W 15.8g
Battery	Exclude
Technical specifications	
Main FMU Processor	STM32F765 (32 Bit Arm® Cortex®-M7, 216MHz, 2MB memory, 512KB RAM)
IO Processor	STM32F100(32 Bit Arm® Cortex®-M3, 24MHz, 8KB SRAM)
On-board sensors	Accel/Gyro: ICM-20689, Accel/Gyro: BMI055, Mag: IST8310, Barometer: MS5611
GPS	ublox Neo-M8N GPS/GLONASS receiver; integrated magnetometer IST8310
Interfaces	
	8-16 PWM servo outputs (8 from IO, 8 from FMU)
	3 dedicated PWM/Capture inputs on FMU
	Dedicated R/C input for CPPM
	Dedicated R/C input for Spektrum / DSM and S.Bus with analog / PWM RSSI input
	Dedicated S.Bus servo output
	5 general purpose serial ports(2 with full flow control, 1 with separate 1.5A current limit)
	3 I2C ports
	1 internal high speed SPI sensor bus with 4 chip selects and 6 DRDYs
	1 internal low noise SPI bus dedicated for Barometer with 2 chip selects, no DRDYs
	1 internal SPI bus dedicated for FRAM, Supports dedicated SPI calibration EEPROM located on sensor module
	1 external SPI buses
	Up to 2 CANBuses for dual CAN with serial ESC
	Analog inputs for voltage / current of 2 batteries
	2 additional analog inputs
Power module output	4.9~5.5V
Max input voltage	6V
Max current sensing	120A
USB Power Input	4.75~5.25V
Servo Rail Input	0~36V
Operating temp	-40~85°C
Storage temp	-40~85°C
Certificates	CE, FCC， RoHS compliant (lead-free)

Arduino Mega



Used for its ADC feature
Communicate with high level computer for ultrasonic sensors data

Tech specs

MICROCONTROLLER	ATmega2560
OPERATING VOLTAGE	5V
INPUT VOLTAGE (RECOMMENDED)	7-12V
INPUT VOLTAGE (LIMIT)	6-20V
DIGITAL I/O PINS	54 (of which 15 provide PWM output)
ANALOG INPUT PINS	16
DC CURRENT PER I/O PIN	20 mA
DC CURRENT FOR 3.3V PIN	50 mA
FLASH MEMORY	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
CLOCK SPEED	16 MHz
LED_BUILTIN	13
LENGTH	101.52 mm
WIDTH	53.3 mm
WEIGHT	37 g

Sensor

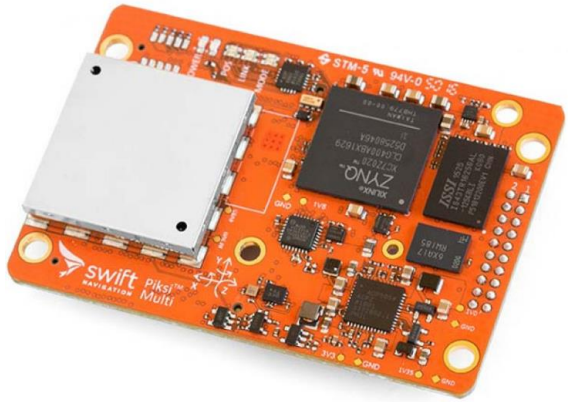
Outdoor Navigation

3DR uBlox GNSS Receiver with compass

Features and Specifications:

ublox LEA-6H module
5 Hz update rate
25 x 25 x 4 mm ceramic patch antenna
LNA and SAW filter
Rechargeable 3V lithium backup battery
Low noise 3.3V regulator
I2C EEPROM for configuration storage
Power and fix indicator LEDs
Protective case
APM compatible 6-pin DF13 connector
Exposed RX, TX, 5V and GND pad
38 x 38 x 8.5 mm total size, 16.8 grams.

Swift Navigation
Piksi GNSS RTK



Features

- Centimeter-level Accurate
- Dual Frequency RTK up to 10Hz:
  - GPS L1/L2
  - GLONASS G1/G2
  - BeiDou B1/B2
  - Galileo E1/E5b
- Raw Measurement output up to 20Hz
- SBAS
- Hardware-ready for:
  - QZSS L1/L2
- On-board MEMS IMU and Magnetometer
- Flexible Interfaces
  - UART
  - Ethernet
  - CAN
  - USB
- Communication Protocols
  - Swift Binary Protocol
  - NMEA 0183
  - RTCM v3
- External Clock Input
- 32 User-definable GPIO Pins for Customization
- Wide power supply range: 5.0 - 15.0 V DC
- Linux Open Platform

TIM561 SICK LiDAR

Range readings
SLAM

Model N°	TIM 561
Accuracy	+-20 mm
Interface	Ethernet
Ambient illuminance	80.000 lux
Ambient temperature / humidity	-25° to +50°
Voltage	9 - 28 VDC
Resolution angle	0.33°
Range	270°
IP	IP67
Environment	Indoors
Distance	0.05- 10 m
Scan frecuency	15 Hz

Ultrasonic Sensor HC-SR04

Obstacle avoidance

General	
Type	Ultrasonic Sensor
Model	HC-SR04
Quantity	1 Piece
Arduino Library	HCSR04Ultrasonic
Power Supply	Working voltage: 3-5.5VDC Static current: less than 2 mA IO logic voltage: 3.3V / 5V
Measurement	Induction angle: not more than 15 degrees Detection range: 2-400 cm Accuracy: 3mm
Compatible	Arduino,NodeMCU

4.
Data Collection

Logitech C920 Camera

Data sent to computer
Visual target tracking

TECHNICAL SPECIFICATIONS

Max Resolution: 1080 p/30 fps - 720p/ 30 fps

Camera mega pixel: 3

Focus type: Autofocus

Lens type: Glass

Built-in mic: Stereo

Mic range: Up to 1 m

Diagonal field of view (dFoV): 78°

Tripod-ready universal mounting clip fits laptops, LCD or monitors [1]

DIMENSIONS

Dimensions including fixed mounting clip

Height: 43.3 mm
Width: 94 mm
Depth: 71 mm
Cable length: 1.5 m
Weight: 162 g

DATA TRANSMISSION AND COLLECTION

BASE STATION

WIFI (SSH)

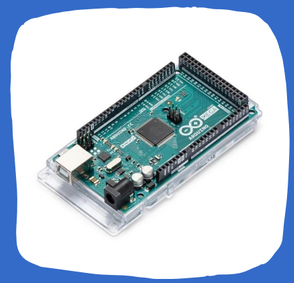
Secure Shell (SSH) Network Protocol is a method for secure remote login from one computer to another.

ARK-1123H

USB A

C920, LOGITECH

USB B



ARDUINO MEGA 2560

USB A

PIXHAWK

ETHERNET

TiM 561 LIDAR, SICK

DATA TRANSMISSION AND COLLECTION

TARANIS X9D REMOTE CONTROLLER

2.4 GHz RF

PIXHAWK PX4

SERIAL RX/TX

3DR UBLOX GNSS RECEIVER

POWER MANAGEMENT

INTERSTATE 12 VOLT 18 AH SEALED LEAD ACID BATTERY (SLA)

- 12V 18Ah batteries
- Rechargeble
- 2-5 operation time, depending on payload velocity
- Robust, have a high cycle ability, a high performance and are easy to maintain

IG52-DB4 Superdroidrobots (Mobile Robot Platform)