COMP0204: Introduction to Programming for Robotics and AI

Lecture 10: Robotics Programming and Applications Overview

Guest Lecture by: Dr Narsimlu Kemsaram

MEng Robotics and AI

UCL Computer Science

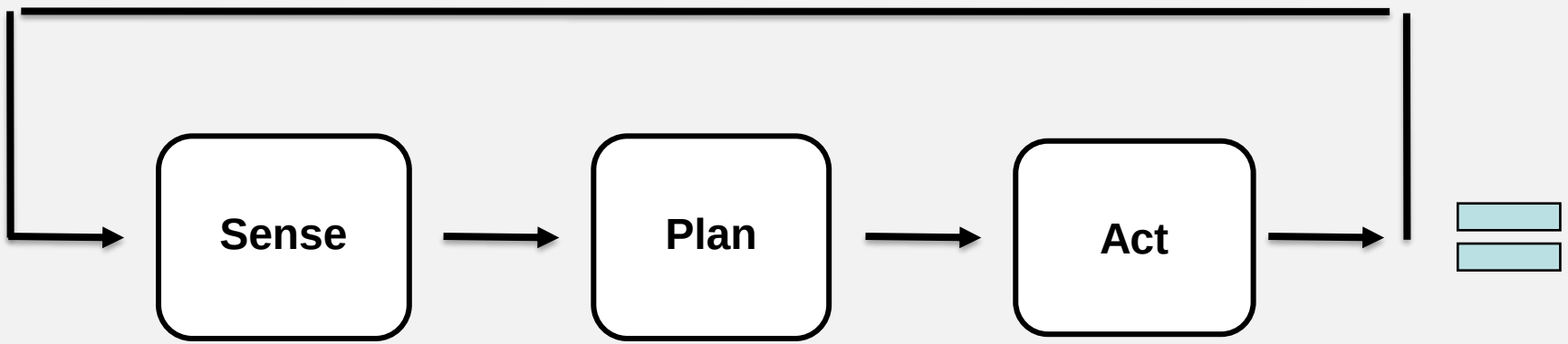
Today's lecture

- Introduction to Robotics
- Robotics in Action – Practical Applications
- Introduction to Arduino IDE
- Robotics Programming with Mona Robot
- Simple Concurrent Programming: Robot Sensing and Control

Introduction to Robotics

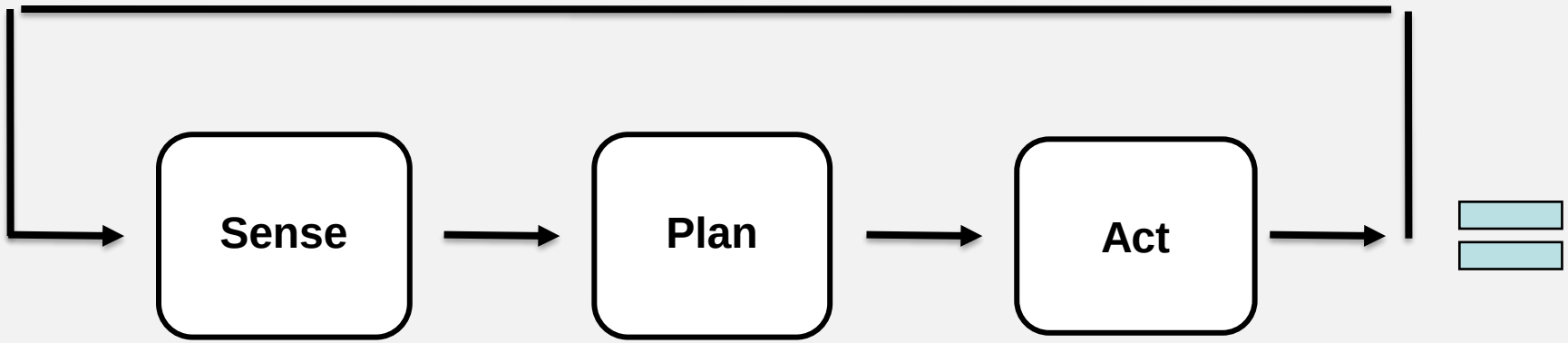
What is a Robot?

- A goal-oriented **machine** that generally can **sense**, **plan** and **act autonomously**.



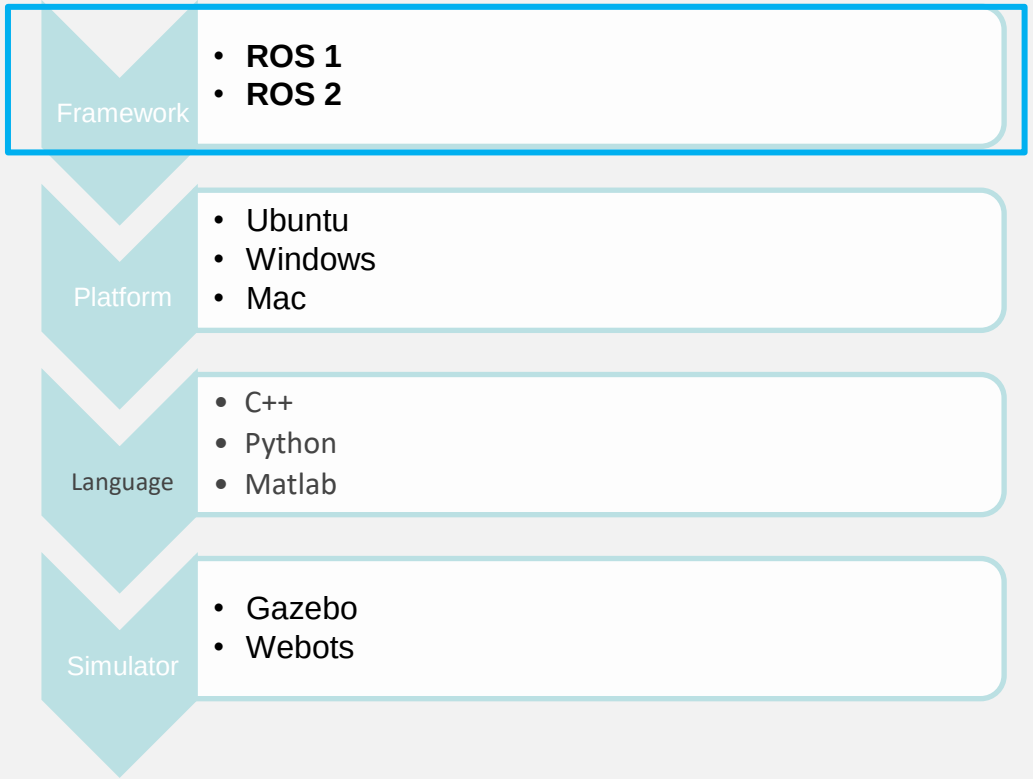
Required Sensors and Algorithms for Robot?

- **Sensors**: Camera, LiDAR, etc.
- **Algorithms**: Mapping, Path Planning, Control, etc.
- **Hardware**: Arduino, Raspberry Pi, Jetson Nano, etc.
- **Software**: ???



Required Software Components for Robotics?

- **Required Software Components for Robotics:**
  - **Framework**
  - **Platform**
  - **Language**
  - **Simulator**



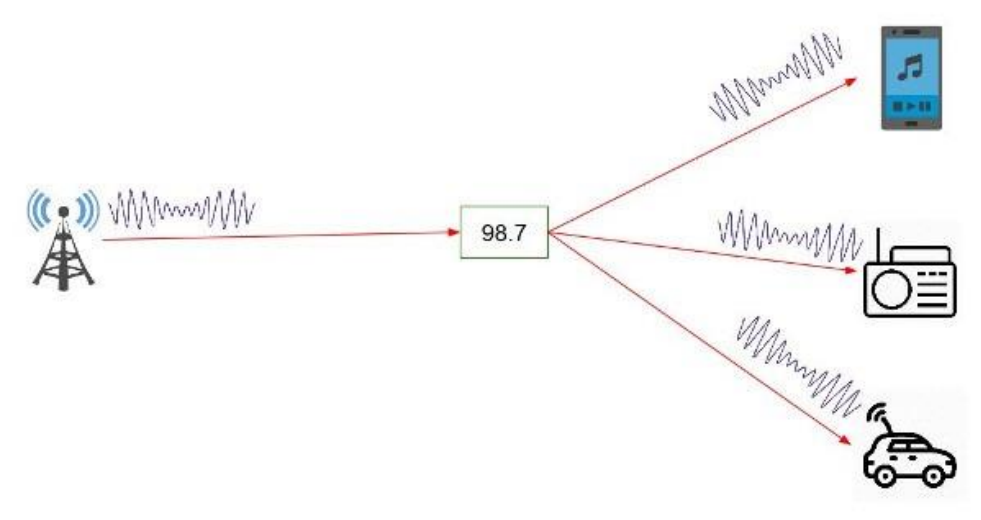
What is ROS?

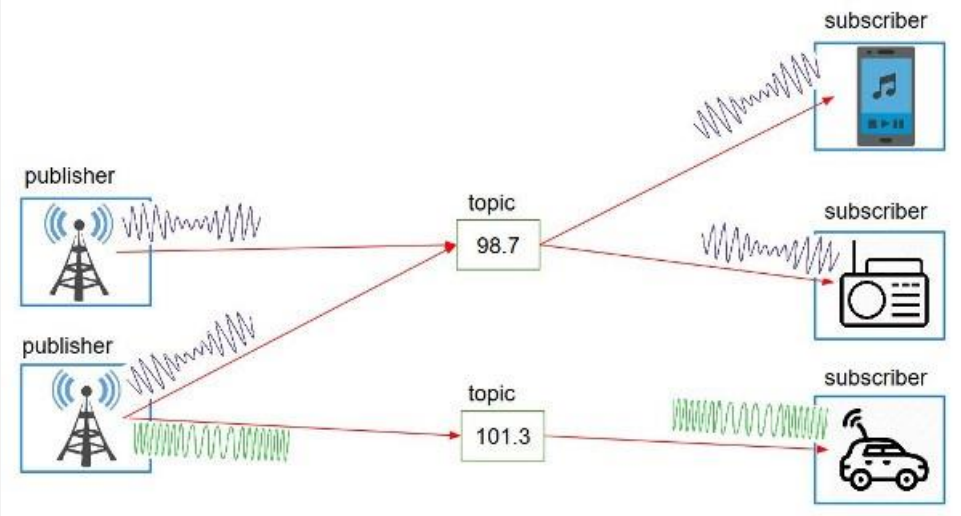
- **ROS = R**obot **O**perating **S**ystem
- **ROS** is a collection of **tools**, **software libraries**, and **documentation**.
- The term "**Operating System**" is a misnomer: **ROS is more like a framework or middleware** plus **a developer community (eco system)**.

ROS.org

- https://www.ros.org/

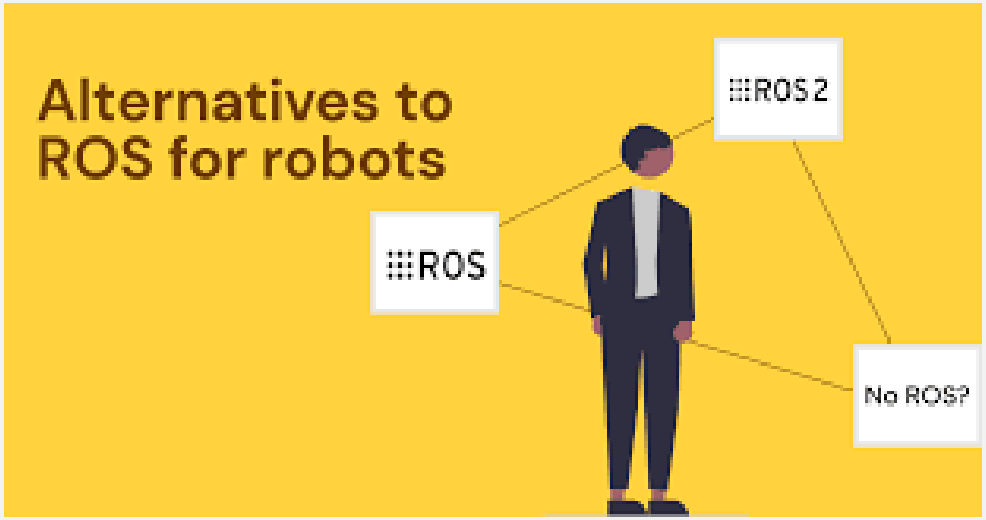
What is ROS Nodes? ROS Topics?





History of ROS?

- Originally developed in **2007** at the **Standford Artificial Intelligence Laboratory**.
- Since **2013** managed by **Open-Source Robotics Foundation (OSRF)**.
- Today used by many **Robots**, **Universities** and **Companies**.
- **De facto Standard for Robot Programming**.



ROS1 to ROS2?

- Since **ROS1** was started in **2007**, a lot has **changed in the robotics** and ROS community.
- In **2020, ROS2** was started.
- The goal of the **ROS 2** project is to adapt to these **changes**, leveraging what is great about ROS 1 and **improving** what isn't.

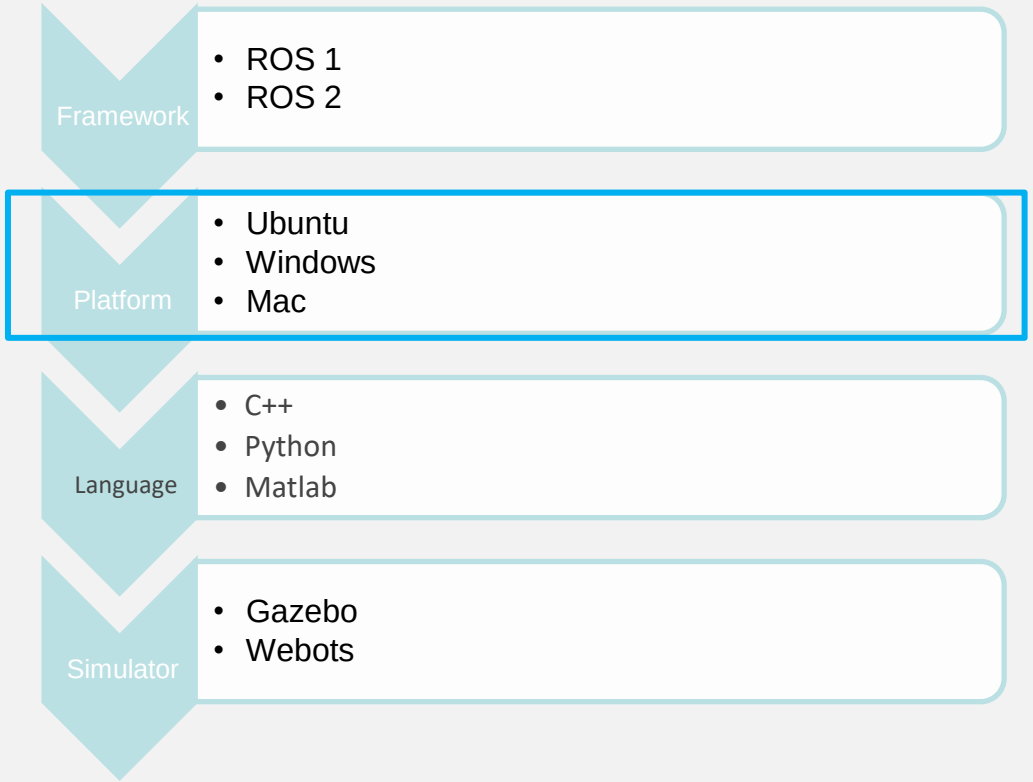
ROS 2 Distribution Releases

Distribution	Release date	Poster	EOL date	Support duration
Rolling Ridley[94][95] (rolling release with latest features)	progressing since June 2020		N/A	N/A
Jazzy Jalisco[2]	May 2024	t.b.d.	EST. May 2029	5 years
Iron Irwini	23 May 2023[96]		**November 2024**	1.5 years
Humble Hawksbill	23 May 2022[97]		May 2027	5 years
Galactic Geochelone	23 May 2021[98]		December 2022	1.5 years
Foxy Fitzroy	5 June 2020[99]		June 2023	3 years

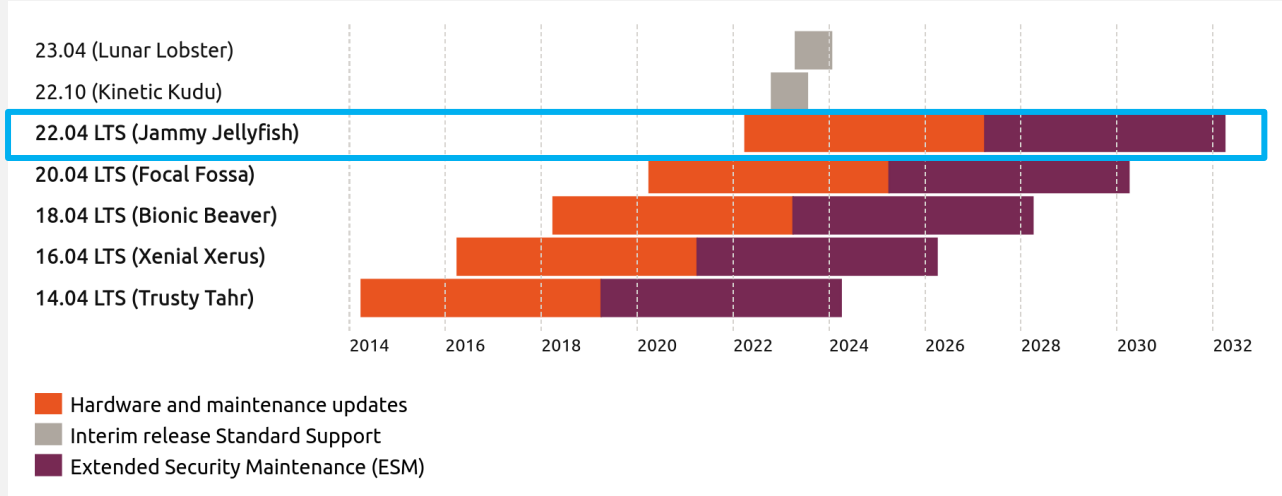
Old version | Older version, still maintained | **Latest version** | Future release

Required Software Components for Robotics?

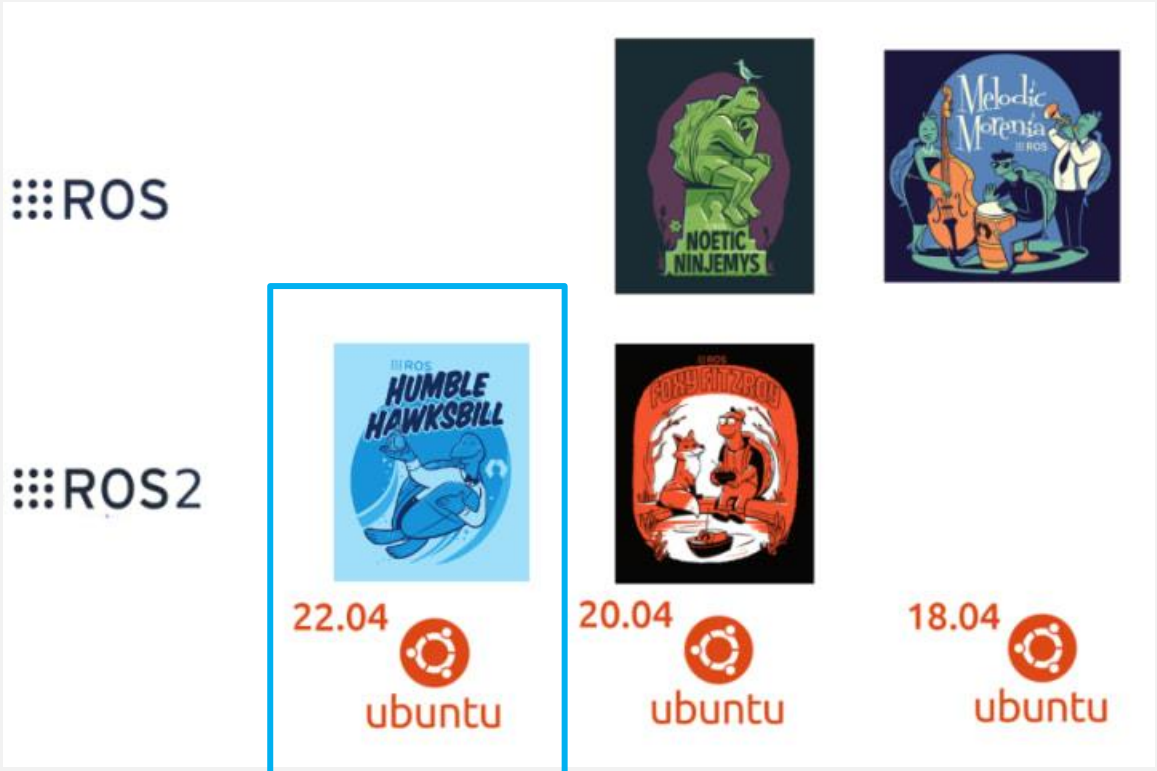
- **Required Software Components for Robotics:**
  - **Framework**
  - **Platform**
  - **Language**
  - **Simulator**



Platform for Robotics: Ubuntu or Windows or Mac



Platform for Robotics: Ubuntu or Windows or Mac

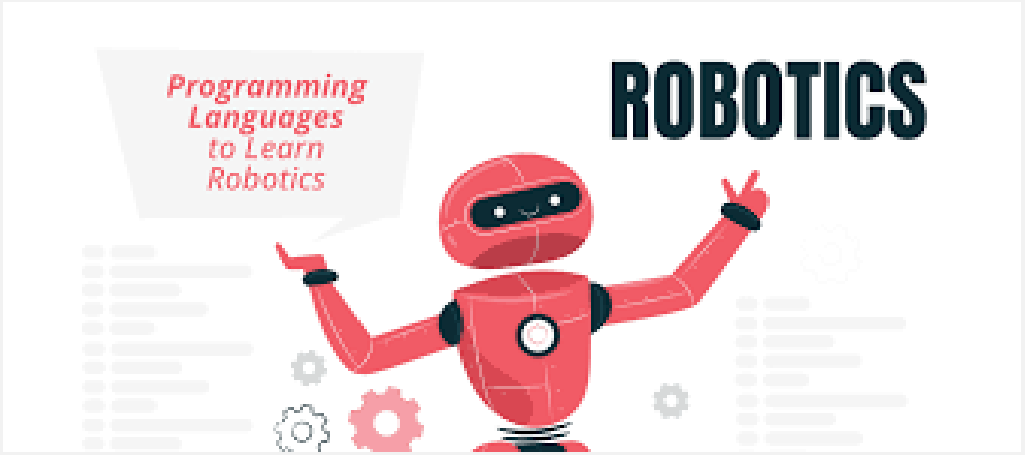


Required Software Components for Robotics?

- **Required Software Components for Robotics:**
  - **Framework**
  - **Language**
  - **Platform**
  - **Simulator**

Programming Language for Robotics

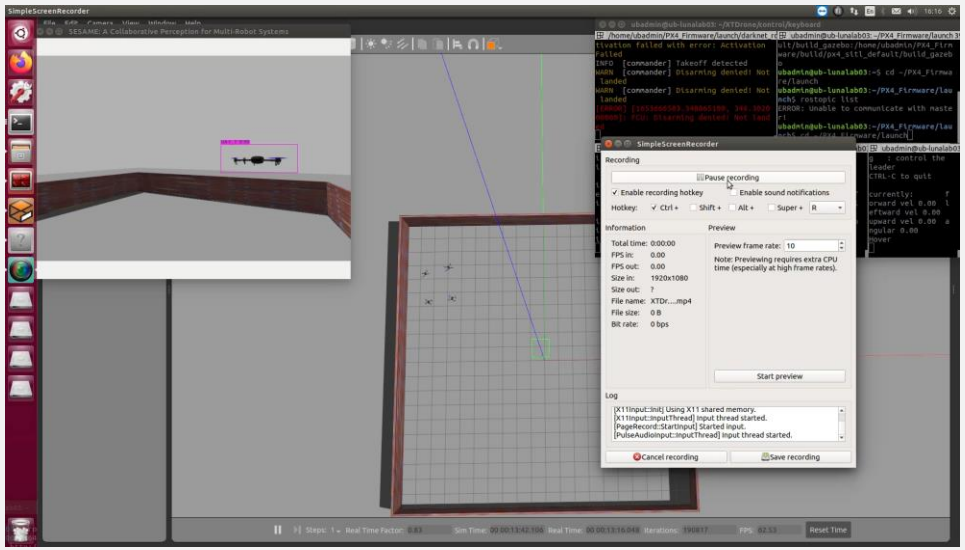
- As such, robotics require **a programming language** that is **versatile, efficient, and easy to use**.
- **C++, Python, and MATLAB** are the most popular programming languages used in robotics, each with their own strengths and weaknesses.

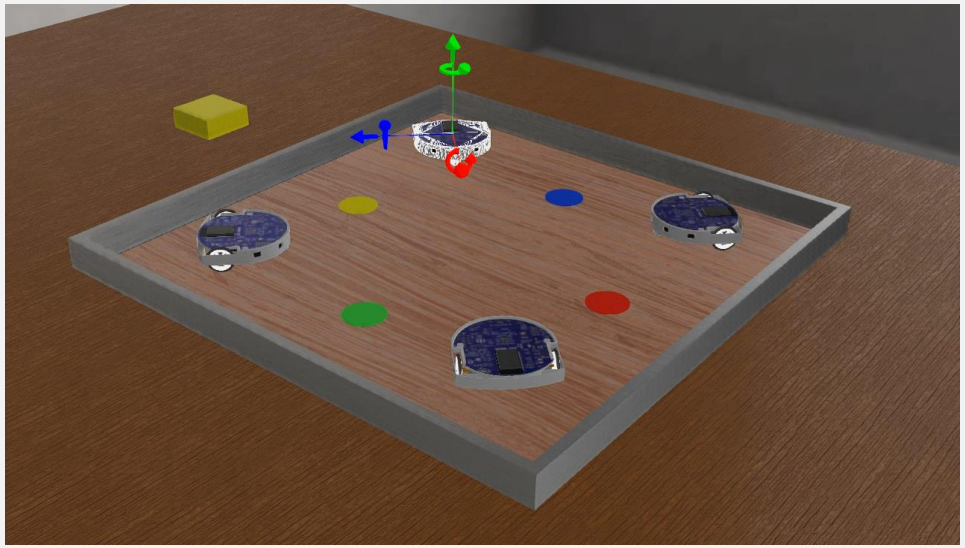


Required Software Components for Robotics?

- **Required Software Components for Robotics:**
  - **Framework**
  - **Language**
  - **Platform**
  - **Simulator**

Simulator for Robotics: Gazebo or Webots



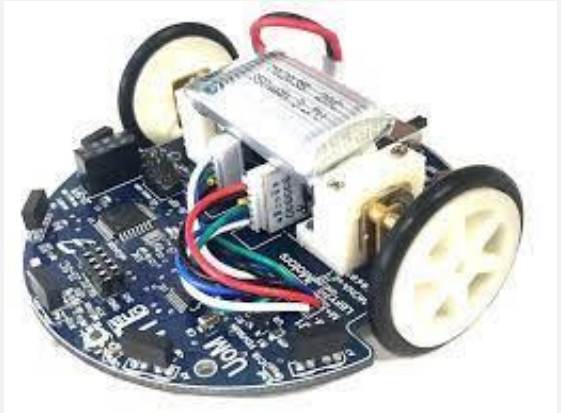


GAZEBO

Webots

robot simulation

Example Robots



Robot Model	Controller/Computer	Sensors	Actuators	Price (€)
BulbRobot (2.2.1)	Raspberry Pi 3 B	2 obstacle avoidance IR; 5 line tracking IR; 1 Ultrasonic; 1 IR receiver; 1 joystick; 1 camera;	2 DC motors; 4 RGB LEDs; 1 servo-motor; 1 buzzer;	122[a]
Mona (2.2.2)	ATmega 328	5 proximity IR; 2 magnetic encoders;	2 DC motors;	118[b]
Khepera IV (2.2.3)	Gumstix Overo FireSTORM COM; dsPIC33FJ64 GS608;	12 IR; 1 IMU; 2 microphones; 1 camera;	2 DC motors; 3 RGB LEDs; 1 speaker;	3240[b][3]
Thymio (2.2.4)	Microchip PIC24F	7 proximity IR; 2 line tracking IR; 1 accelerometer; 1 thermistor; 1 microphone;	2 DC motors; 39 LEDs; 1 speaker;	151.75[c]
E-puck (2.2.5)	Microchip dsPIC30F6014A	8 proximity IR; 1 accelerometer; 1 gyroscope(later versions); 3 microphones; 1 camera;	2 stepper motors; 1 speaker; 9 red LEDs; Set of green LEDs;	878[b]
E-puck2 (2.2.5)	STM32F407	8 proximity IR; 1 ToF; 1 IMU with magnetometer; 4 microphones; 1 camera; 1 IR receiver; 1 rotary switch;	2 stepper motors; 1 speaker; 5 red LEDs; 4 RGB LEDs; Set of green LEDs;	878[b]
Robobo (2.2.6)	PIC32 based; Phone processor;[d]	4 motor encoders; 8 IR; Phone sensors;[d]	2 movement motors; 2 phone support motors; 7 RGB LEDs; Phone actuators;[d]	399[24]

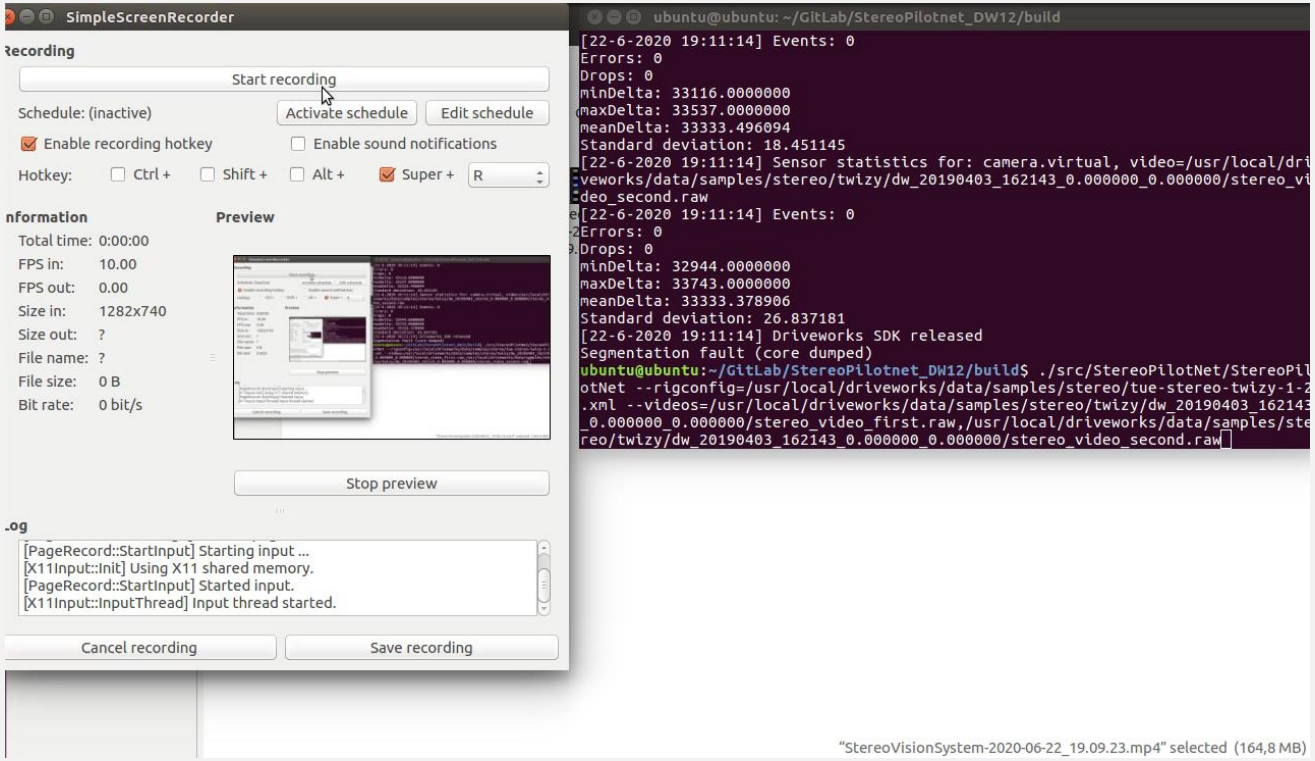
- https://www.ros.org/robots/

Robotics in Action – Practical Applications

Robotics in Action – Practical Applications

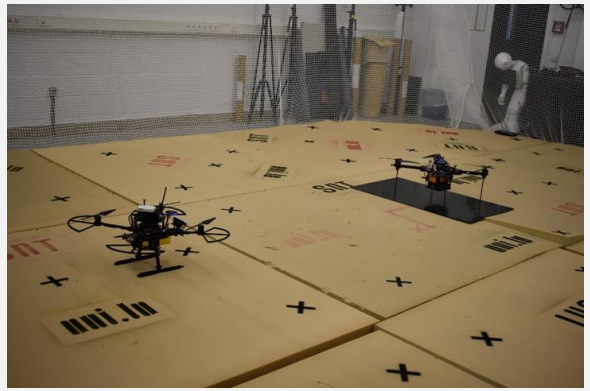
- Autonomous Ground Vehicles (AGVs)
- Unmanned Aerial Vehicles (UAVs)
- Mars Exploration Rovers (MERs)
- Robotics in Medical

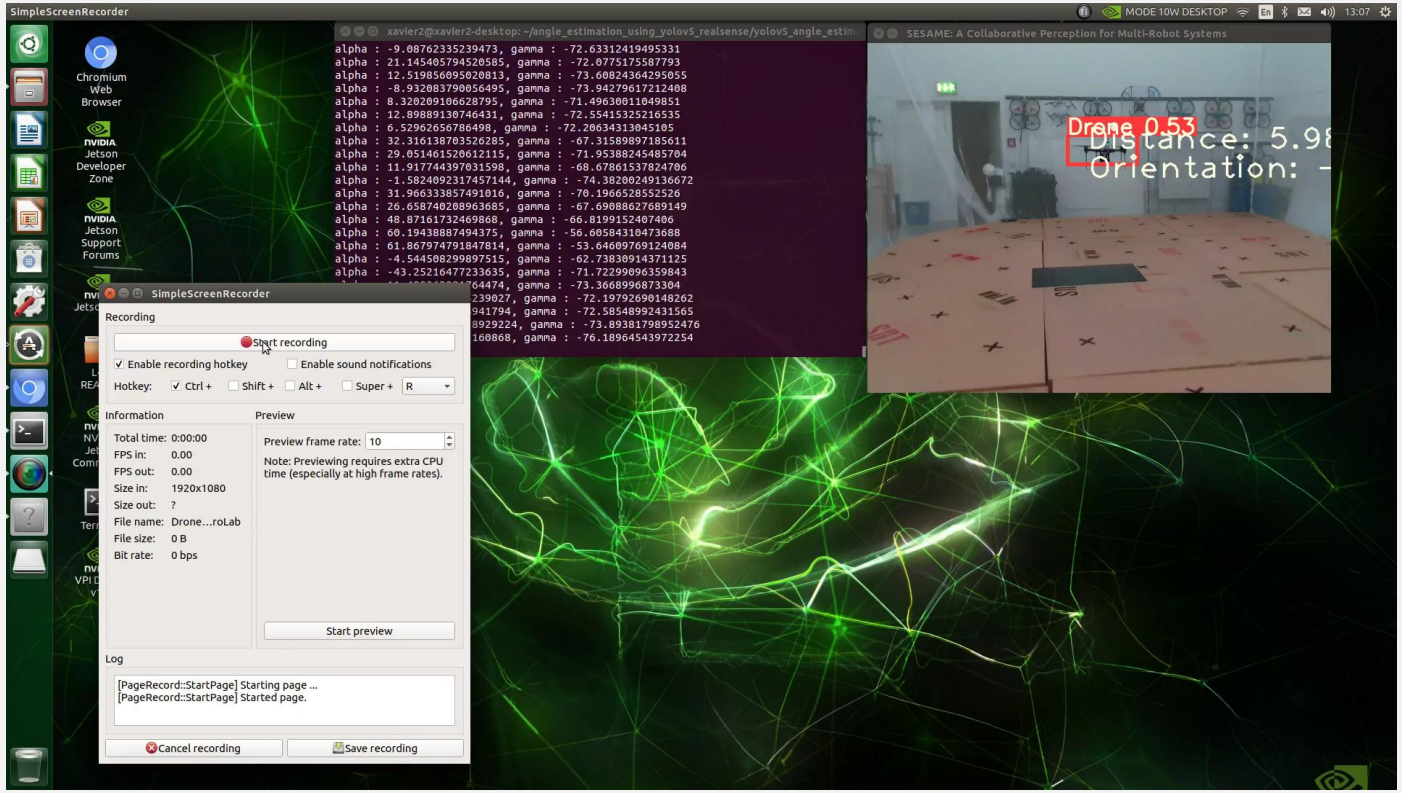
Autonomous Ground Vehicles (AGVs)



- Narsimlu Kemsaram, Anweshan Das, and Gijs Dubbelman. **A Stereo Perception Framework for Autonomous Vehicles**. In 2020 IEEE 91st Vehicular Technology Conference (VTC), Antwerp, Belgium, 25-28 May 2020.

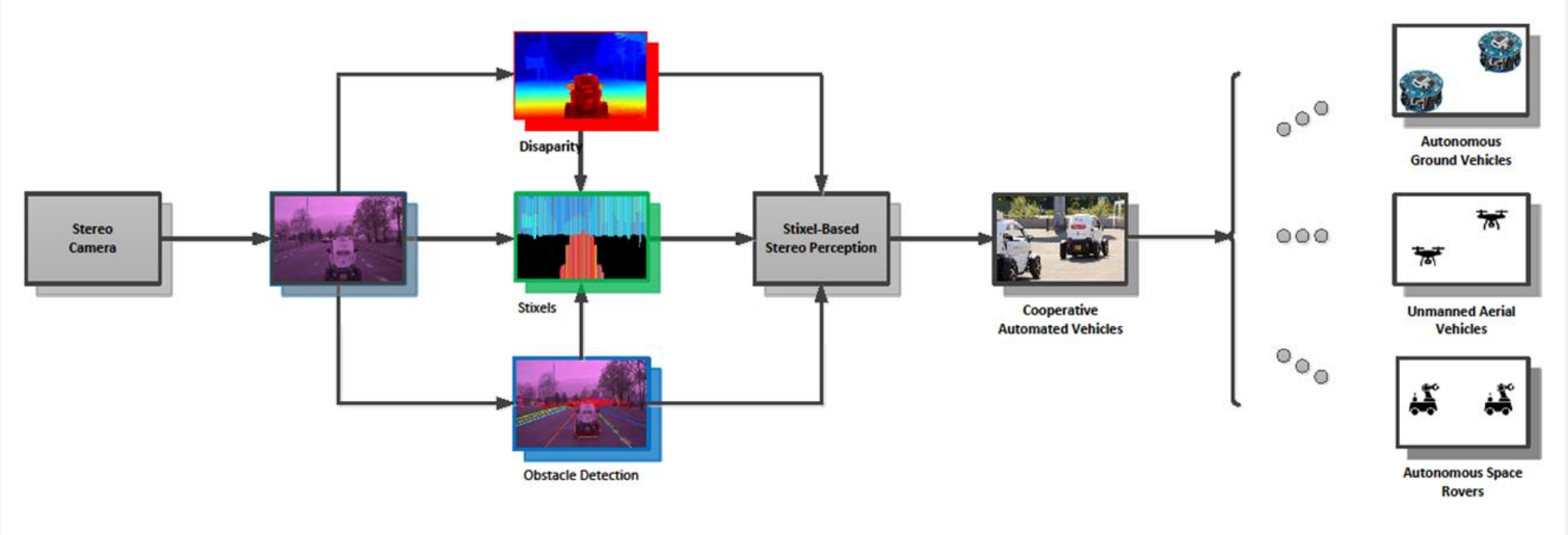
Unmanned Aerial Vehicles (UAVs)





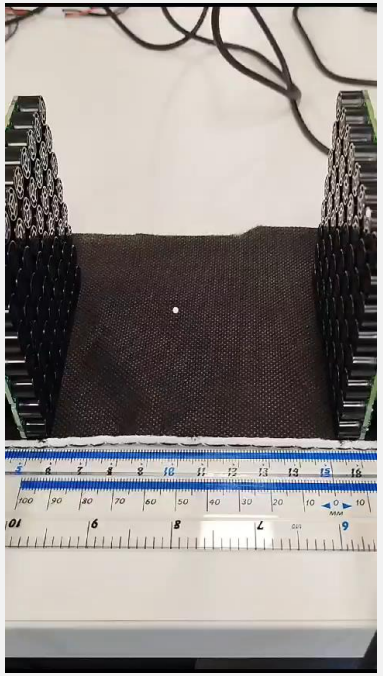
- Narsimlu Kemsaram, Antoine Richard, Sumit Goski, Junlin Song, Abhishek Bera, Miguel Olivares-Mendez. **An Onboard Perception Framework for Multi-UAV Systems** (Submission In Progress).

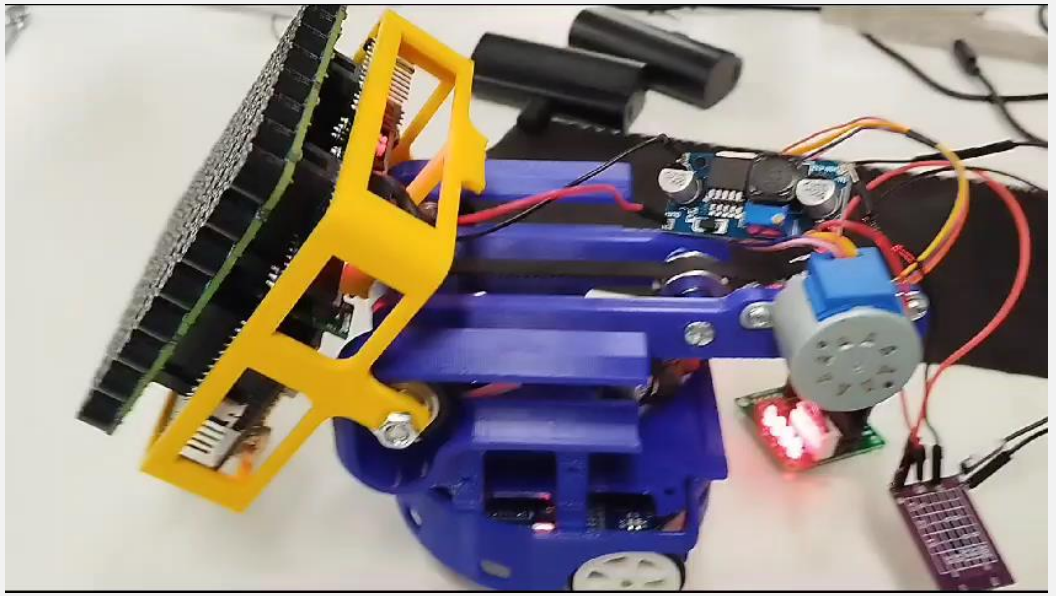
Mars Exploration Rovers (MERs)



- Narsimlu Kemsaram, Anweshan Das, and Gijs Dubbelman. **A Stixel-Based Stereo Perception for Multi-Robot Systems** at the AIAA Aviation 2023 Forum Conference, 12-16 June 2023, San Diego, CA, USA.

Swarm Robotics



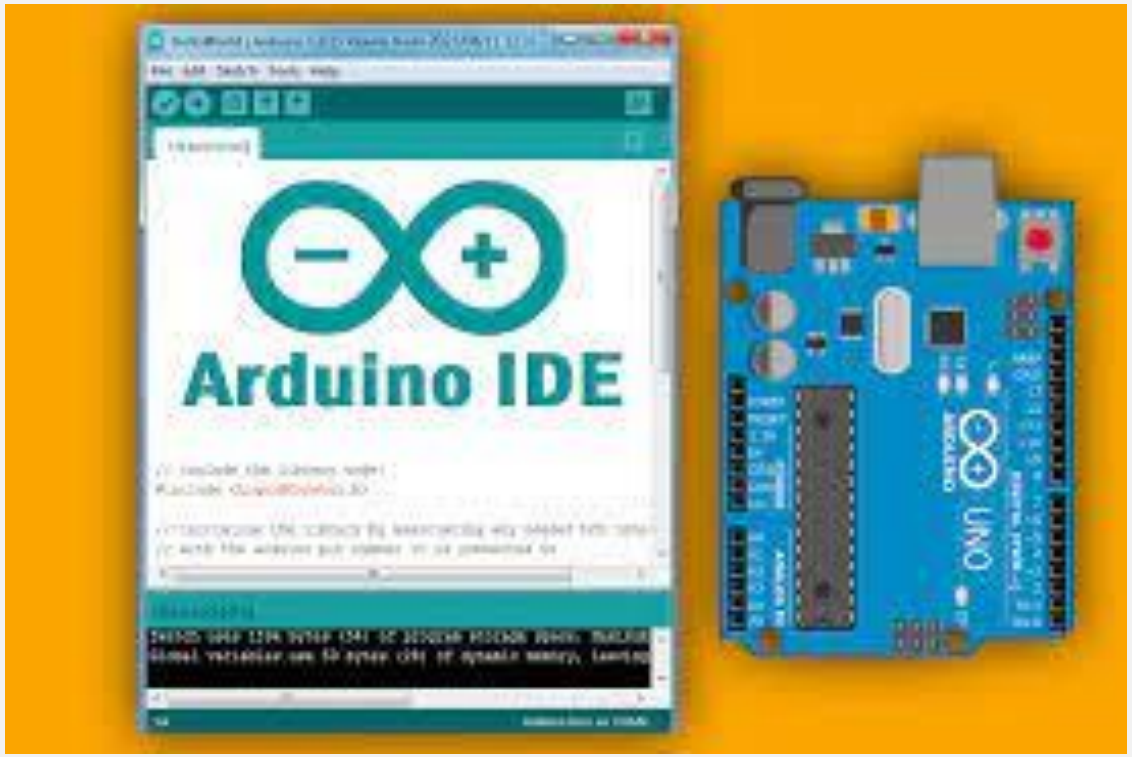


- **AcoustoBots: Acoustic, self-actuated, multi-modal bots for tangible tabletop interactions** (In Progress).

Robotics in Medical

Introduction to Arduino IDE

Robotics Programming: Arduino IDE

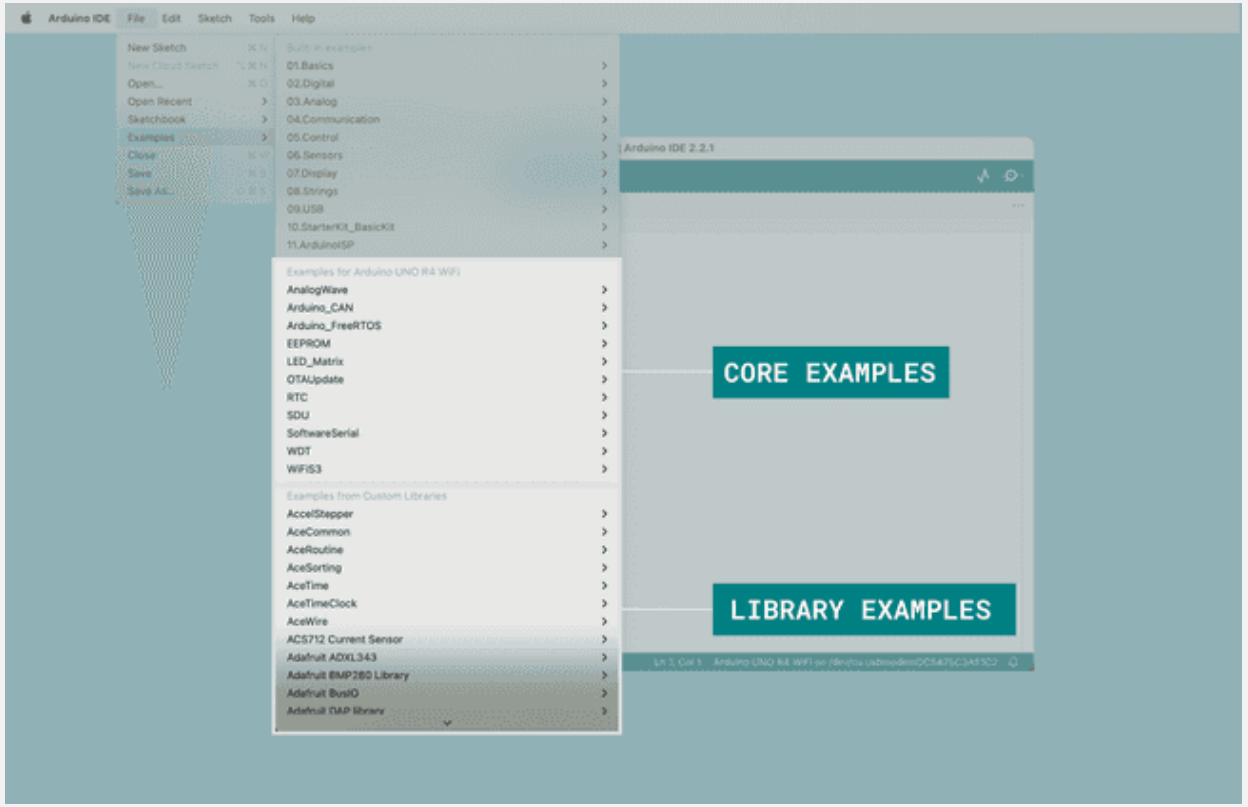


- https://www.arduino.cc/en/software.

Robotics Programming: Arduino IDE

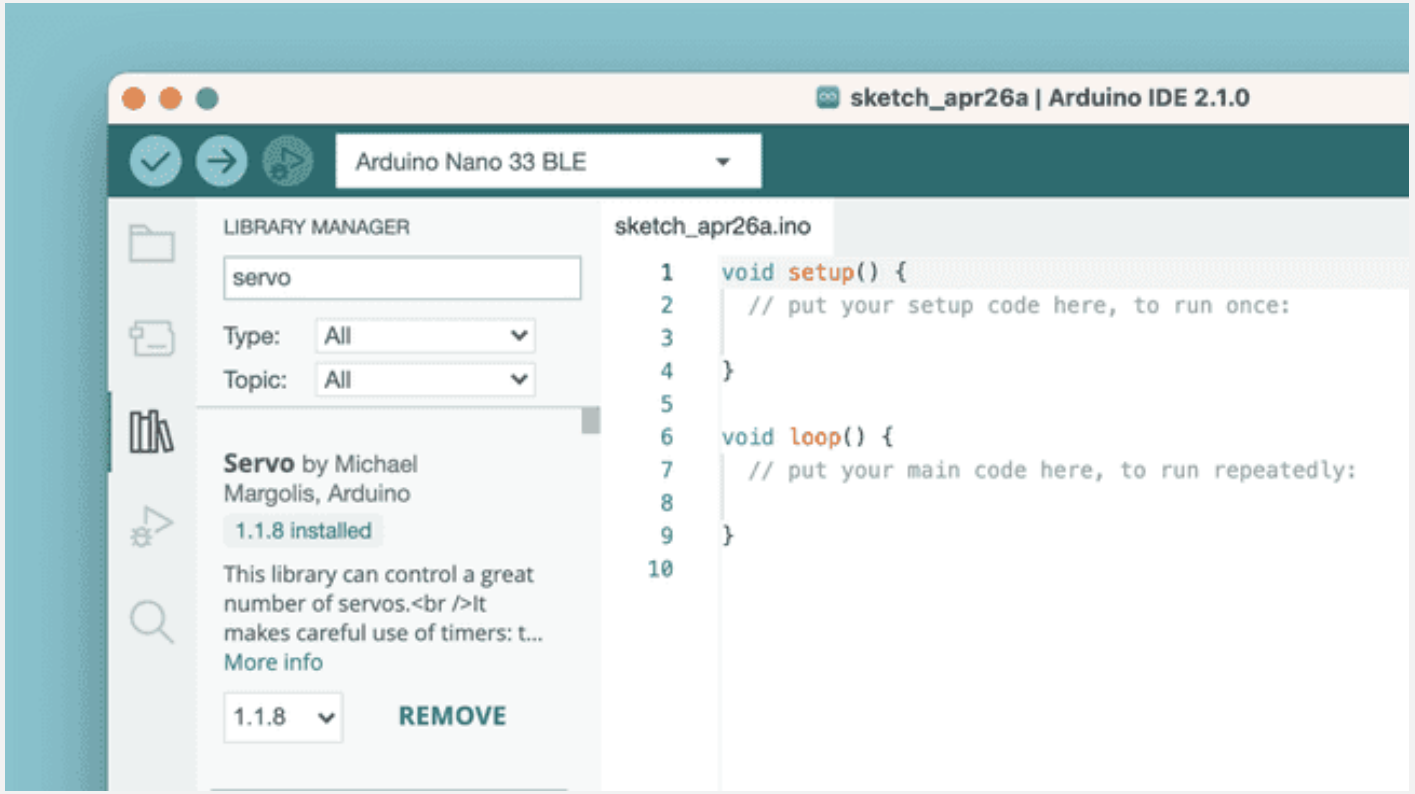
- https://www.arduino.cc/en/software.

Robotics Programming: Arduino IDE



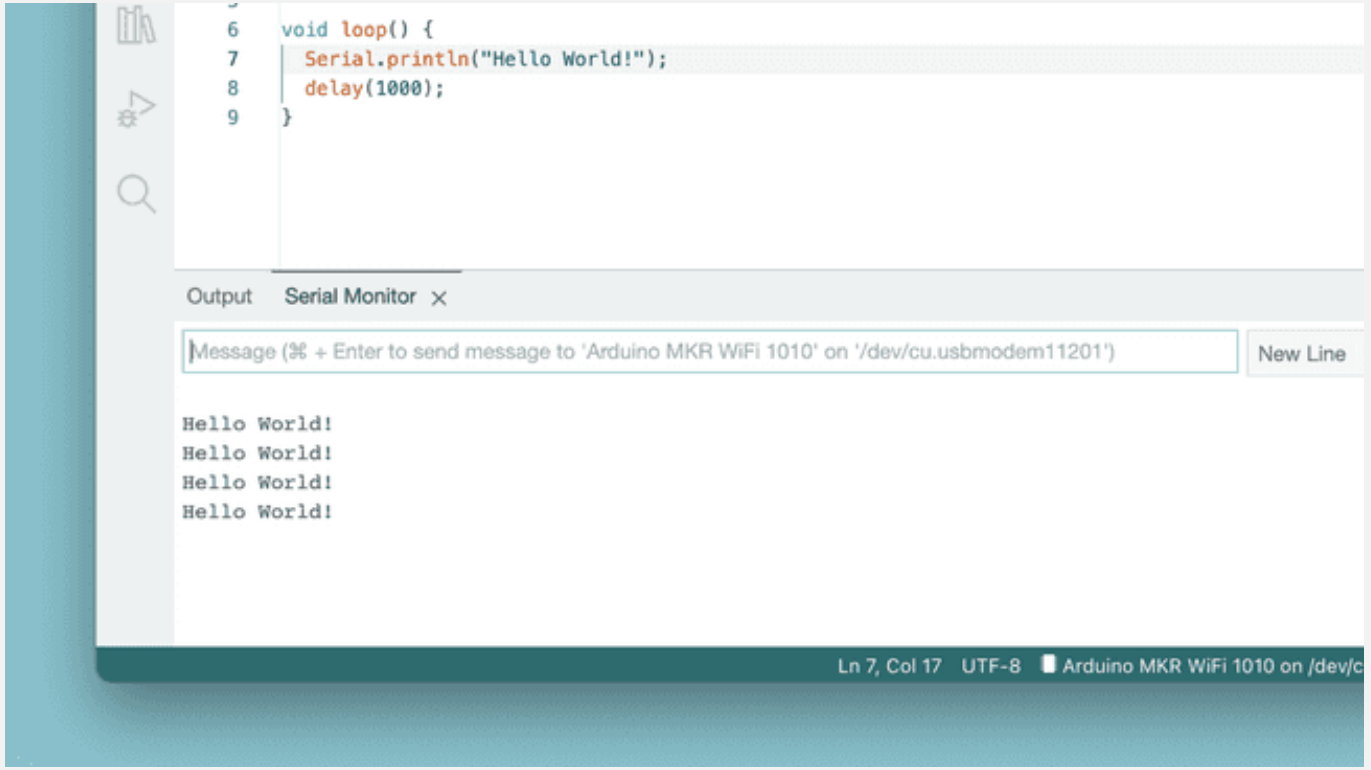
- https://www.arduino.cc/en/software.

Robotics Programming: Arduino IDE



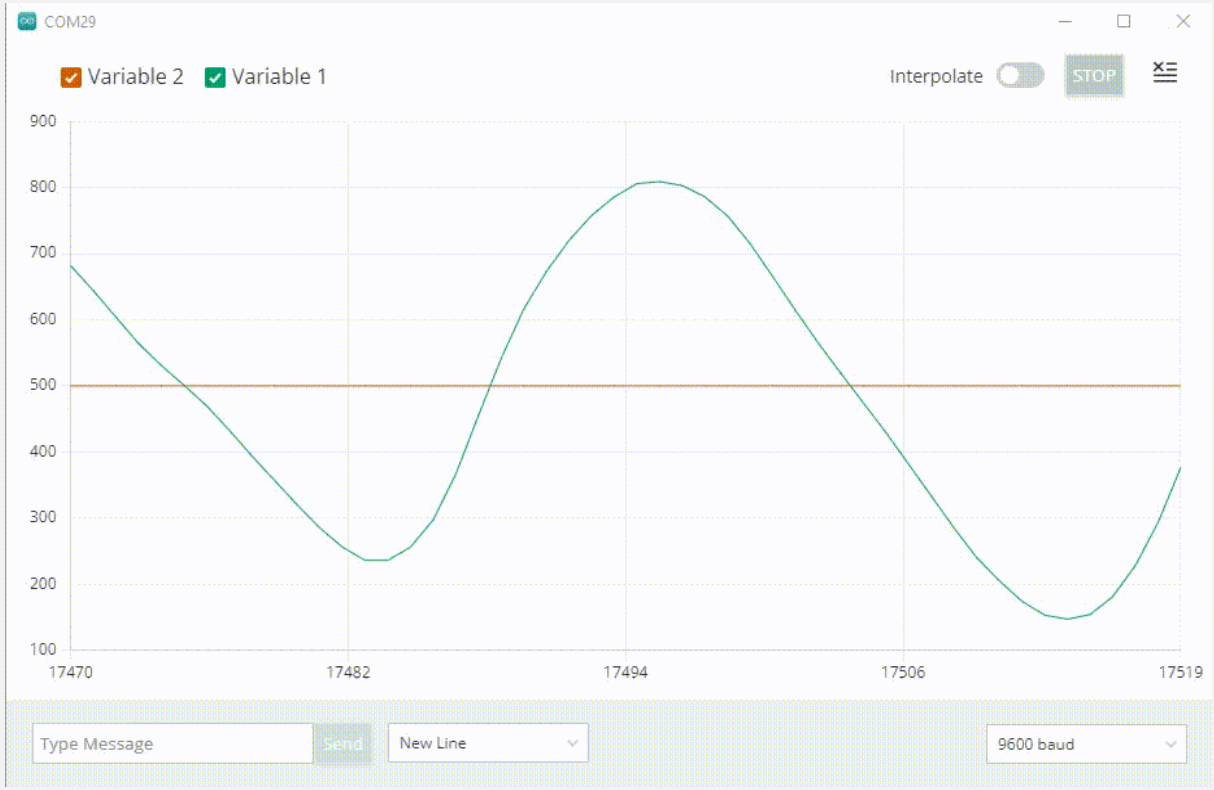
- https://www.arduino.cc/en/software.

Robotics Programming: Arduino IDE – Serial Monitor



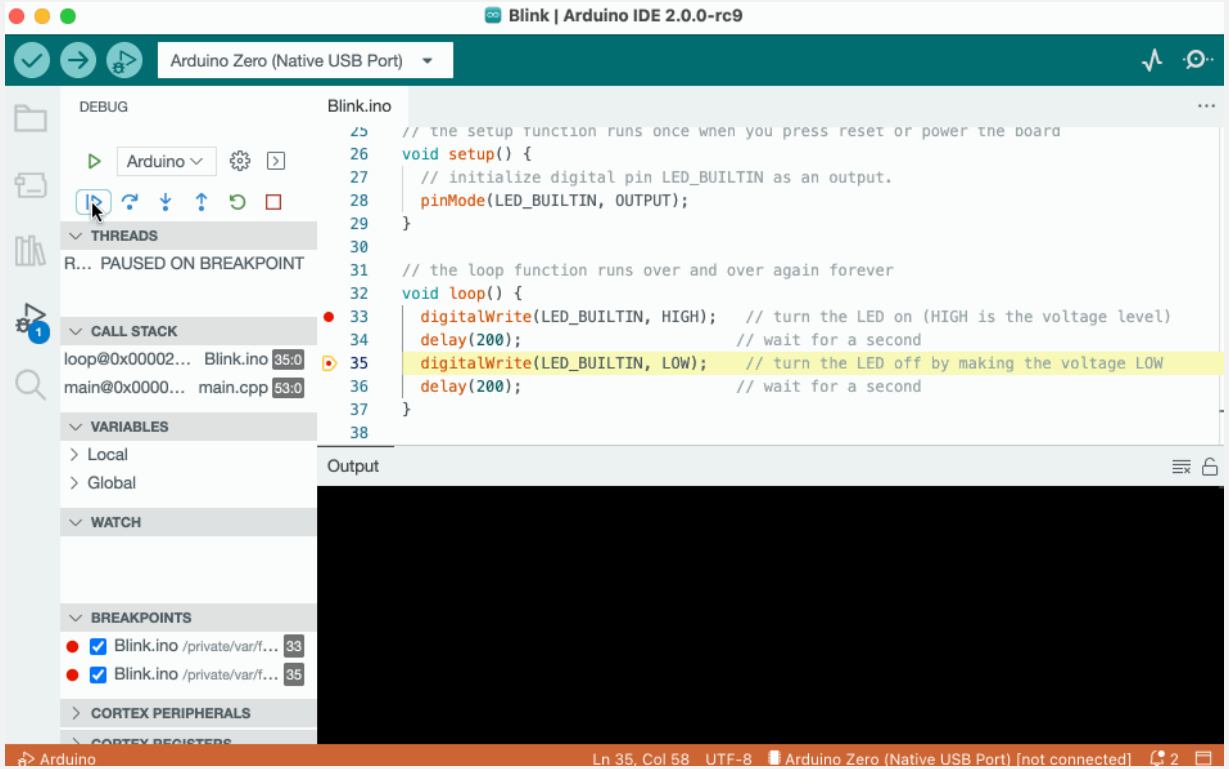
- https://www.arduino.cc/en/software.

Robotics Programming: Arduino IDE – Serial Plotter



- https://www.arduino.cc/en/software.

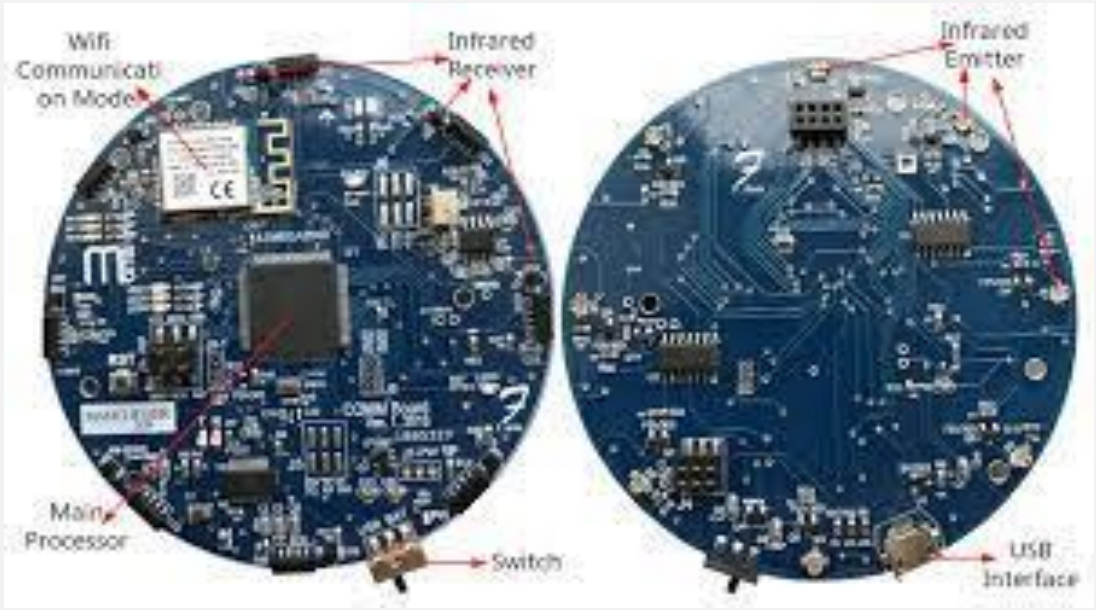
Robotics Programming: Arduino IDE – Debugging

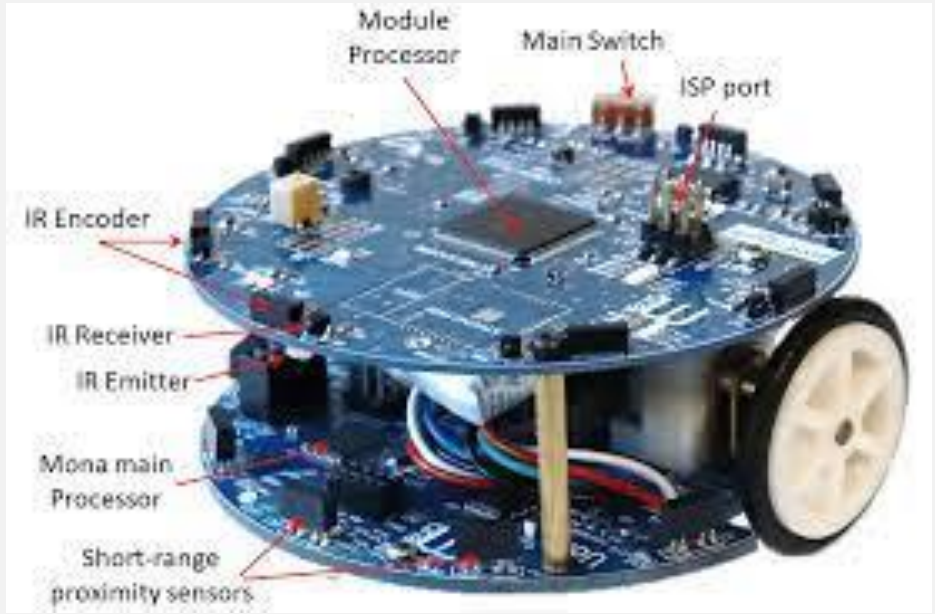


- https://www.arduino.cc/en/software.

Robotics Programming: Mona Robot

Robotics Programming: Mona Robot





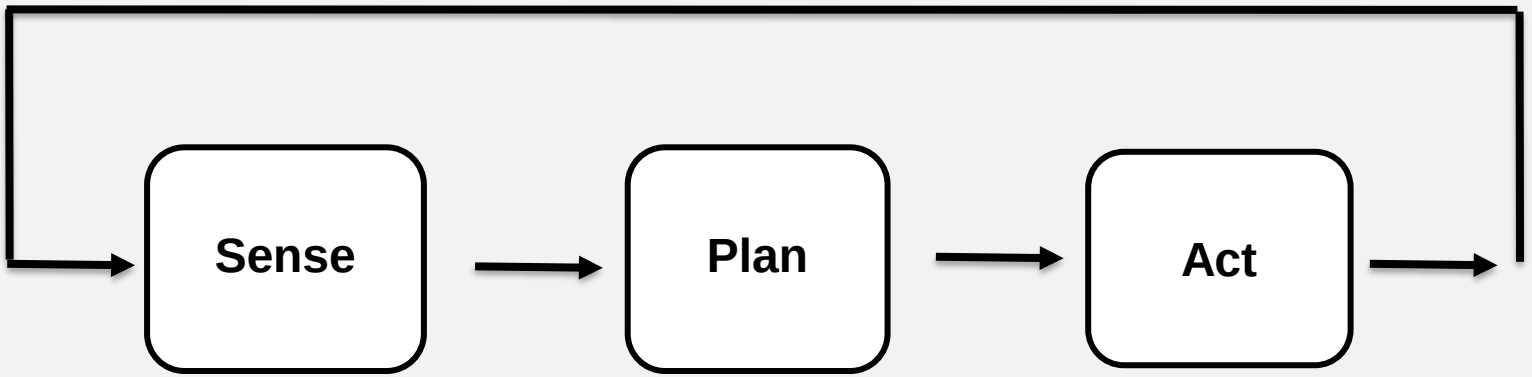
- https://github.com/MonaRobot/Mona-Platform.

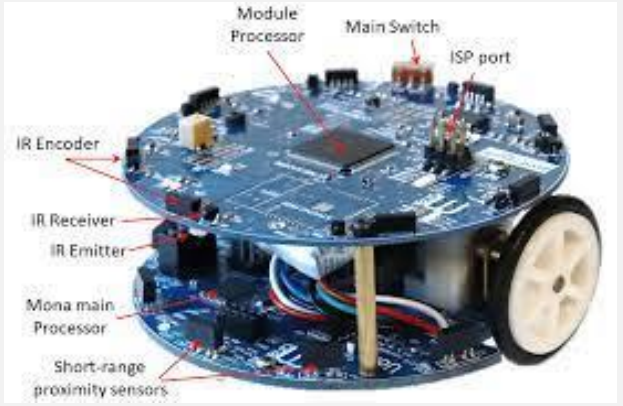
Robotics Programming: Mona Robot

Robotics Programming: Sense, Plan, and Control

Robotics Programming: Sense, Plan, and Control

- A goal-oriented **machine** that generally can **sense**, **plan** and **act autonomously**.

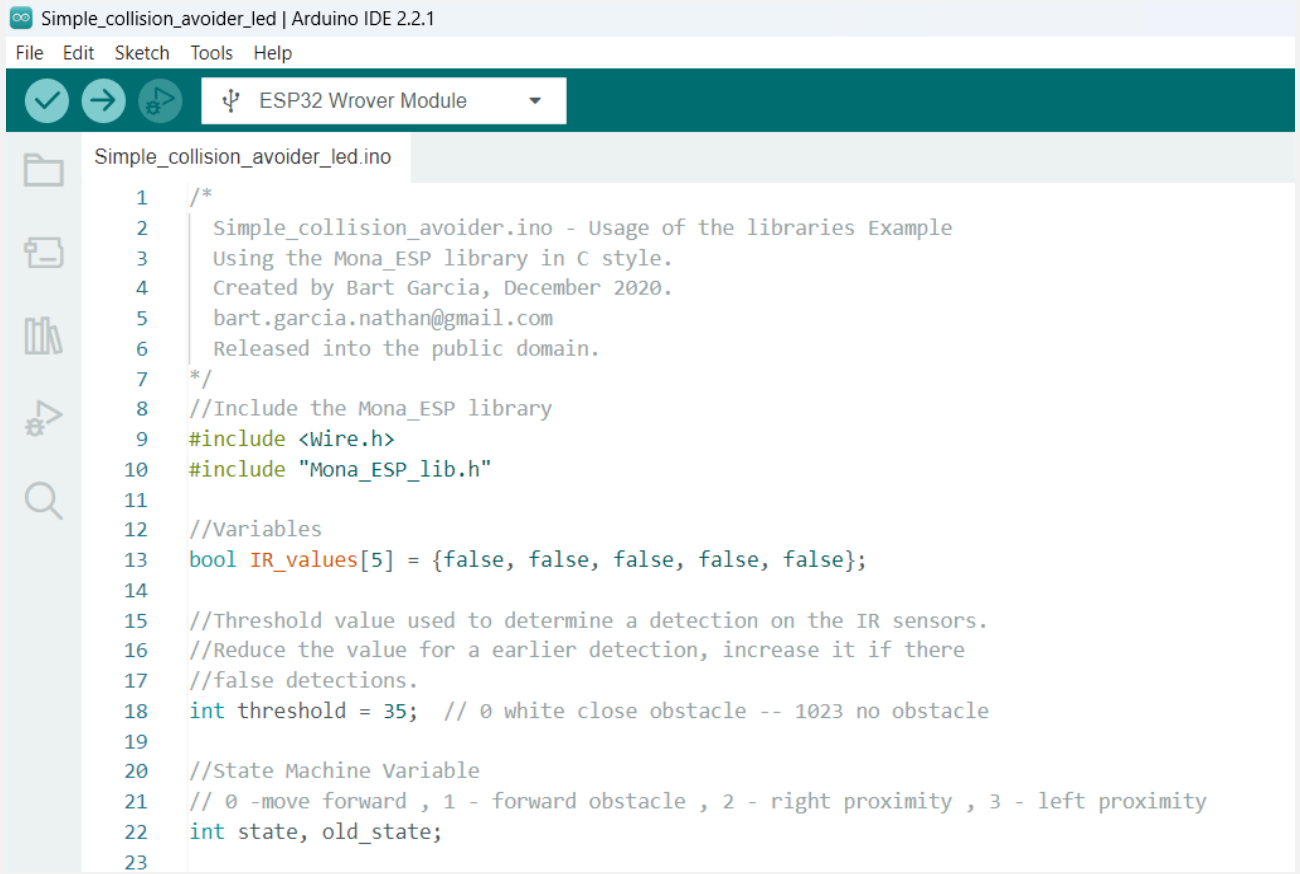




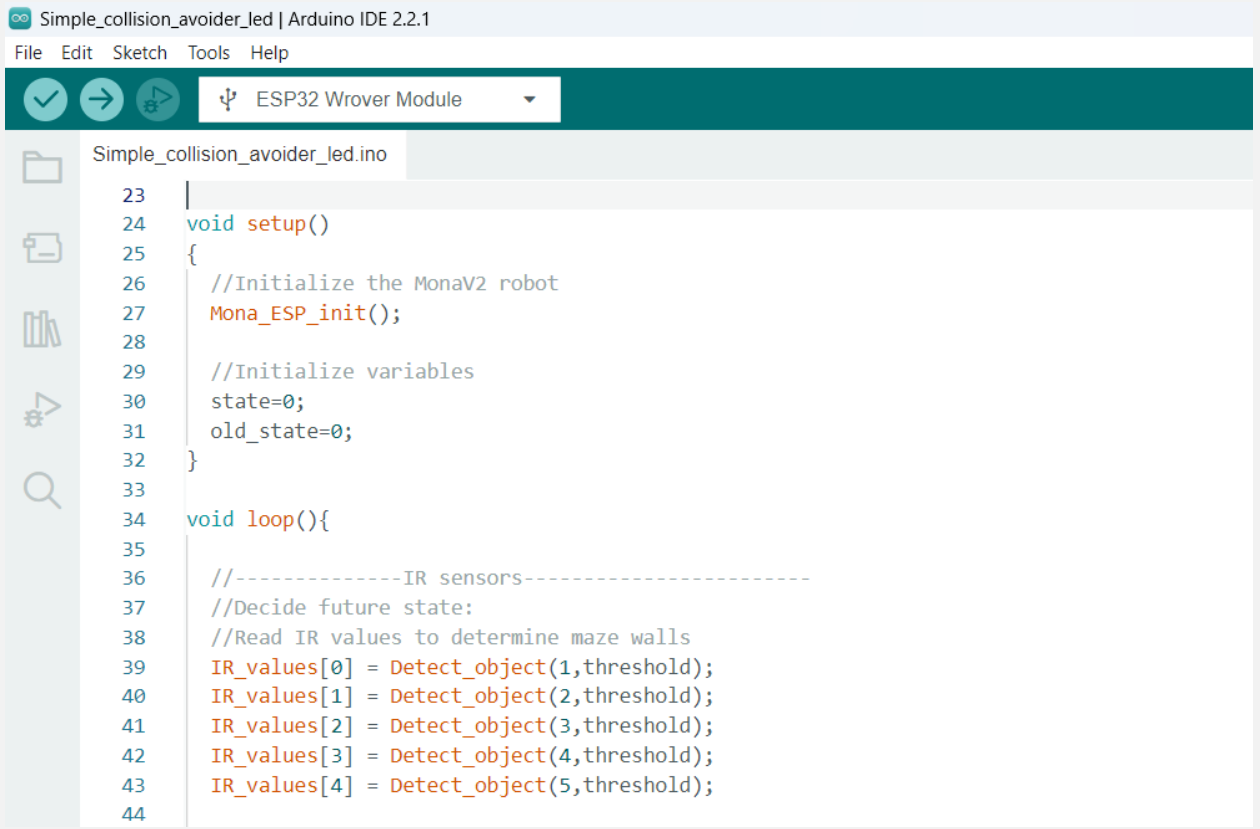
Robotics Programming: Pre-requisites

- Arduino IDE
- Mona Robot
- ESP32 Libraries
- Arduino Collision Avoidance Code

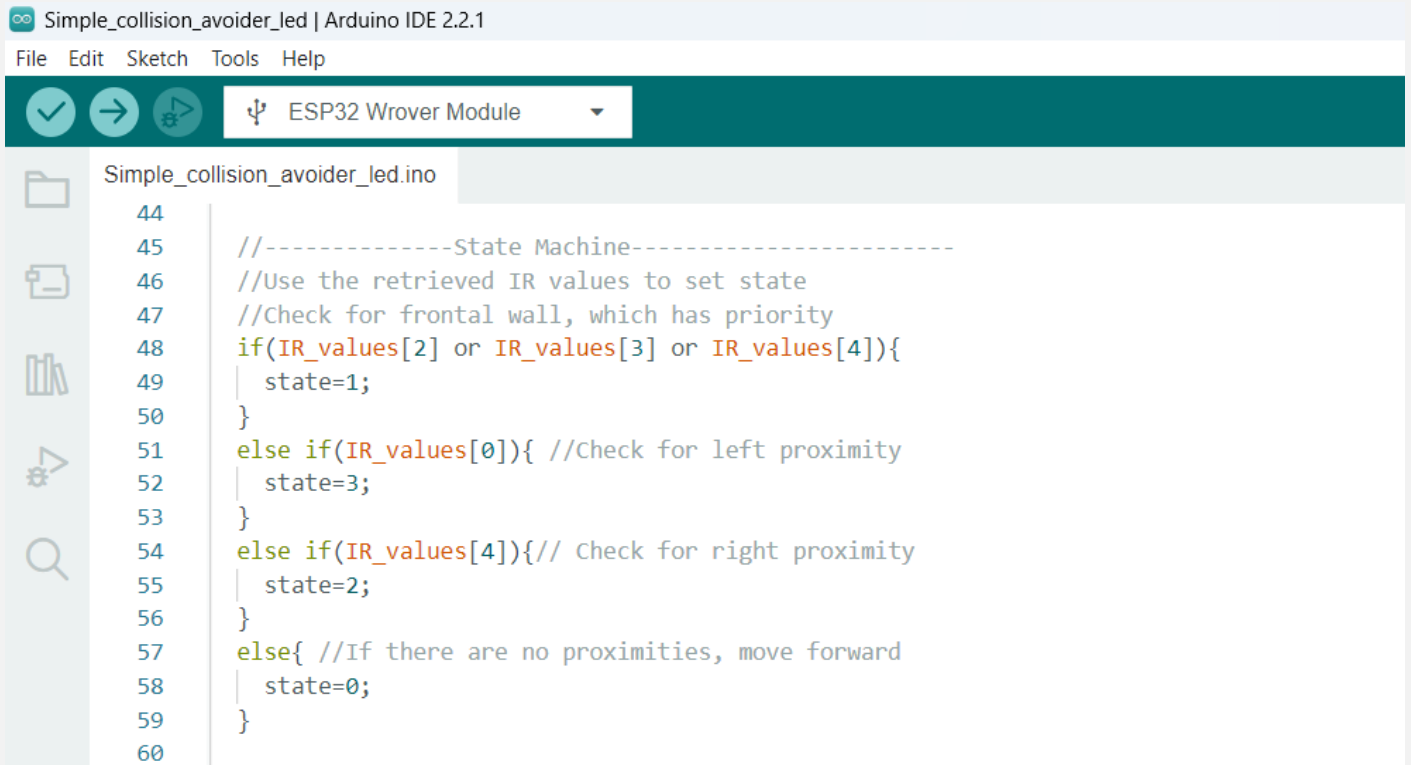
Robotics Programming: Sense, Plan, and Control



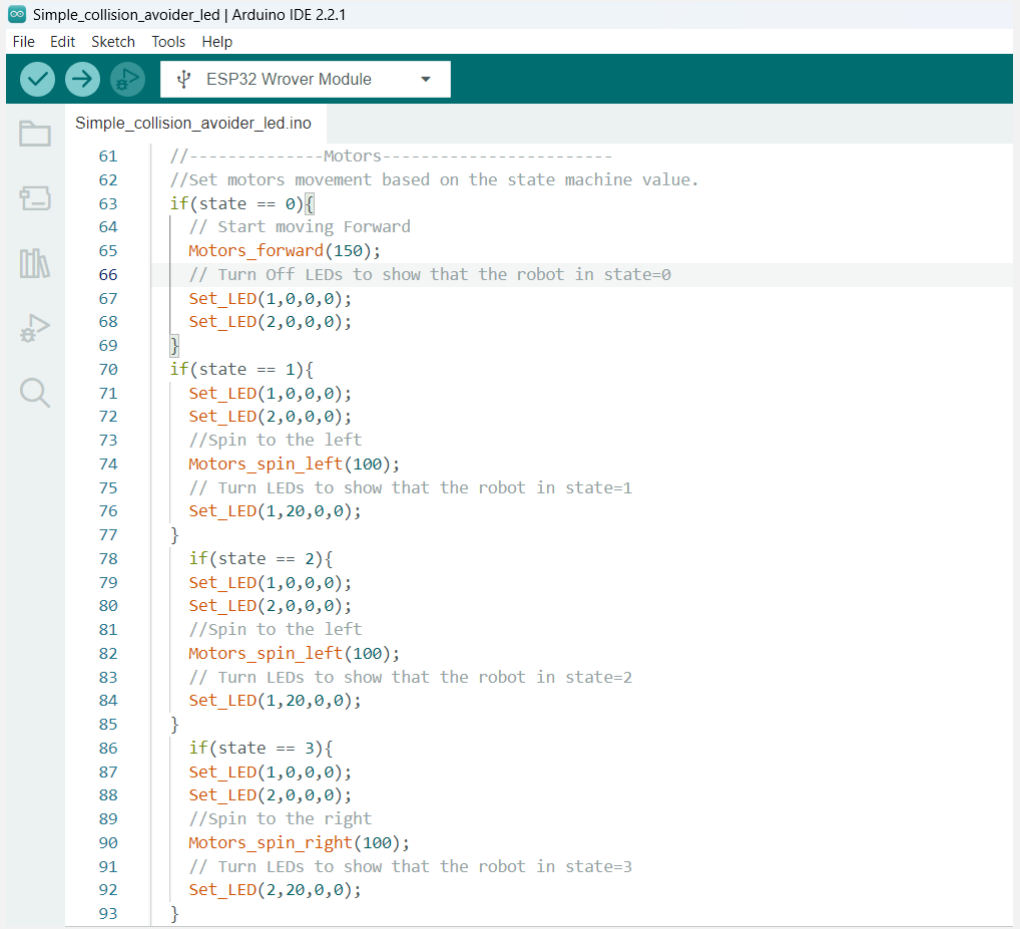
Robotics Programming: Sense, Plan, and Control



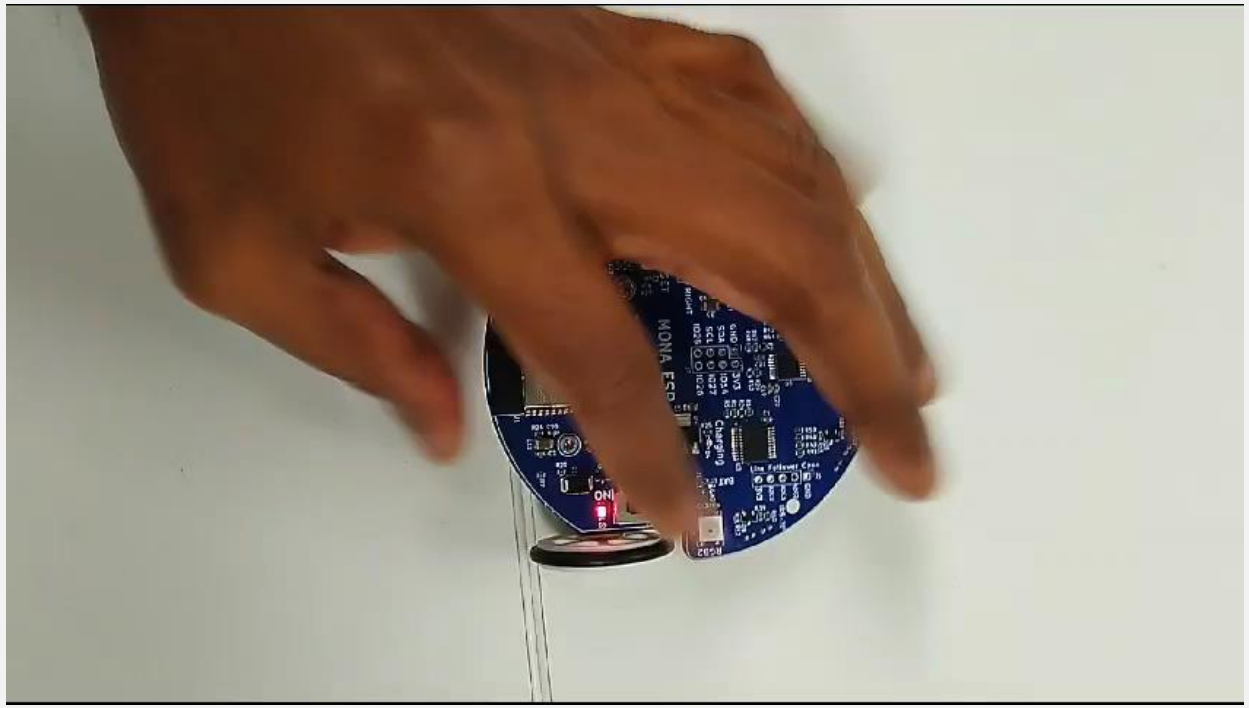
Robotics Programming: Sense, Plan, and Control



Robotics Programming: Sense, Plan, and Control



Robotics Programming: Sense, Plan, and Control



Robotics Programming: Sense, Plan, and Control

Demo: Deploy Code onto the Mona Robot!

Thank you!