

AD ASTRA

EMBEDDED SYSTEMS & ROBOTICS

BY NISHAANT

www.adastracit.com



PART I: THE FOUNDATIONS

Microcontrollers, Architectures, and Comparisons

EMBEDDED SYSTEM BASICS

Definition

A specialized computing system designed to perform a specific task within a larger mechanical or electrical system. Unlike a PC, it is dedicated to one function.

Key Components

Consists of a Processor (Brain), Memory (Storage), I/O Ports (Communication), and the Firmware (Code) that orchestrates interactions.



HISTORY OF MICROCONTROLLERS



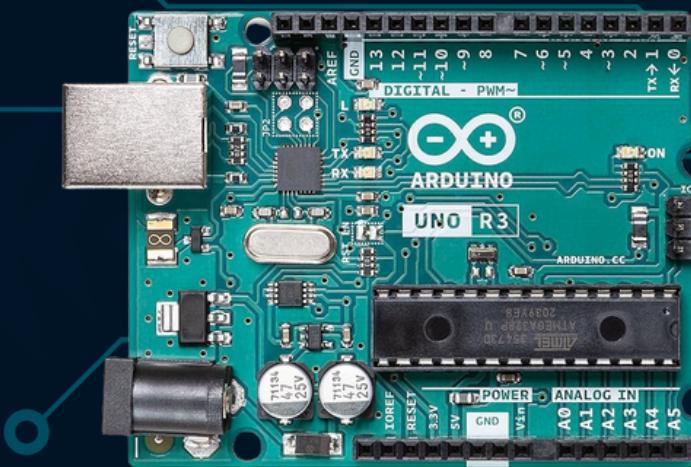
1971

TI TMS 1000
First 4-bit MCU
ever produced.



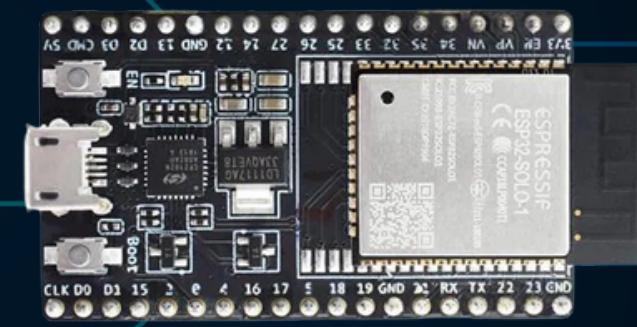
1980

Intel 8051
Industry
standard for
legacy industrial
systems.



2004

Arduino (AVR)
The revolution
of open-
source DIY
hardware.



2016

ESP32
Modern era:
Integrated
Wi-Fi and
Bluetooth.

COMPARISON OF ARCHITECTURES

Feature	8051 Series	AVR (Arduino)	ARM (STM32)	ESP32
Bit Width	8-bit	8-bit	32-bit	32-bit (Dual Core)
Clock Speed	~12 MHz	16 MHz	72-400 MHz	Up to 240 MHz
Connectivity	None	UART/I2C/SPI	Advanced Bus	Wi-Fi + BLE
Flash Memory	Low (4KB+)	Medium (32KB)	High (512KB+)	Massive (4MB+)

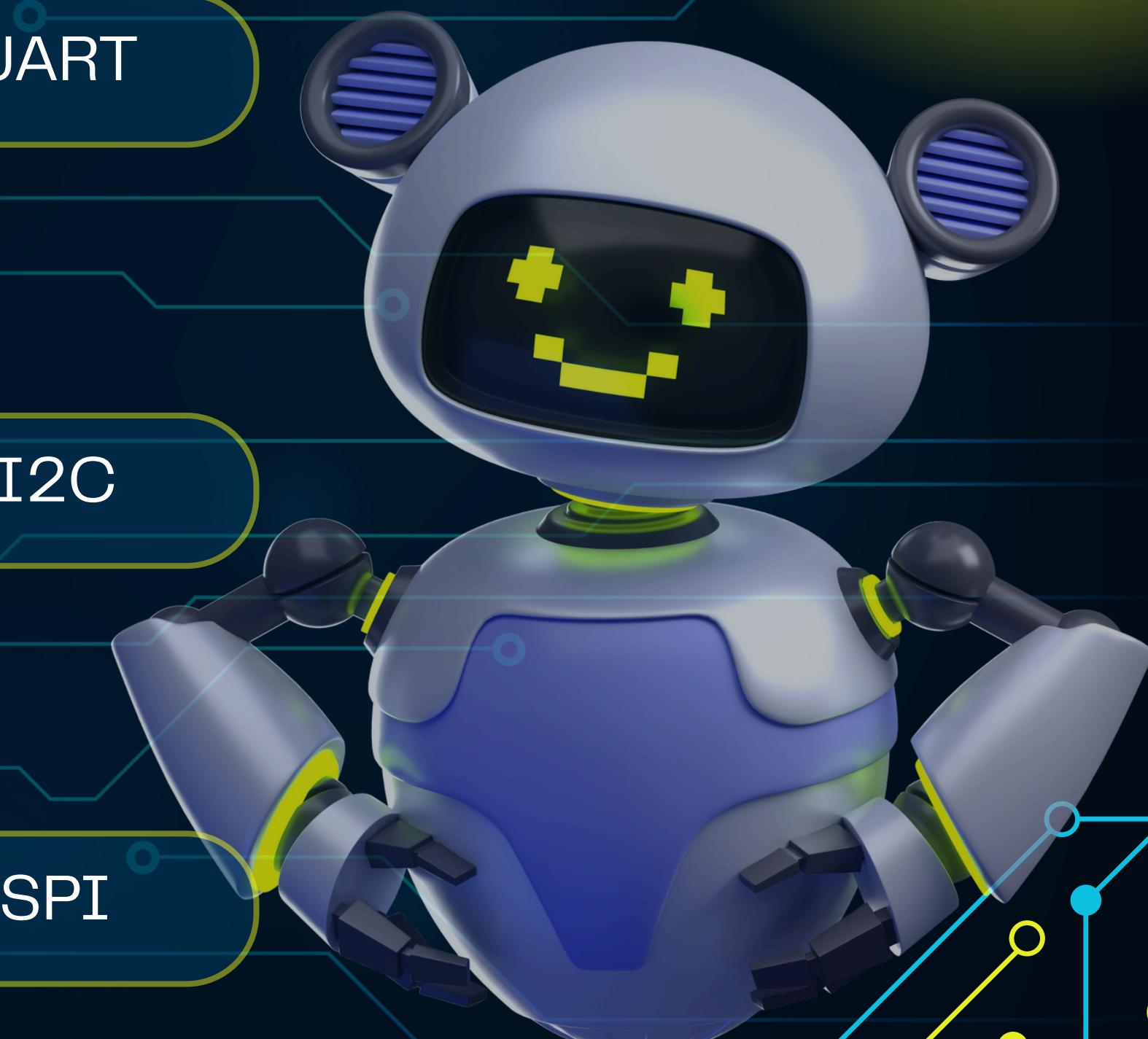
COMMUNICATION PROTOCOLS

- ▶ Universal Asynchronous Receiver-Transmitter. Point-to-point, simple 2-wire communication (TX/RX) without a clock signal.
- ▶ Inter-Integrated Circuit. Uses 2 wires (SDA/SCL) to connect multiple sensors and peripherals via unique addressing.
- ▶ Serial Peripheral Interface. High-speed 4-wire interface for displays and SD cards requiring rapid data transfer.

UART

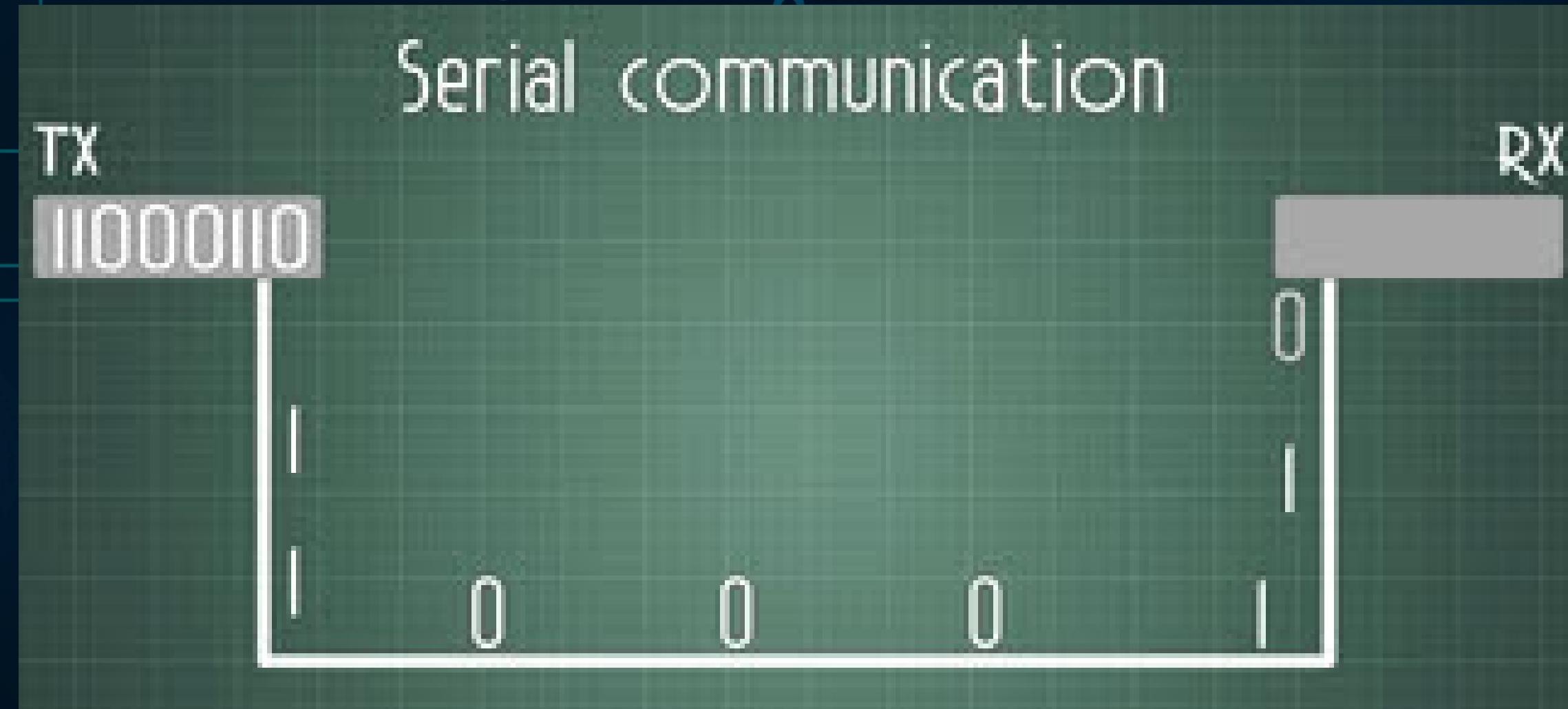
I2C

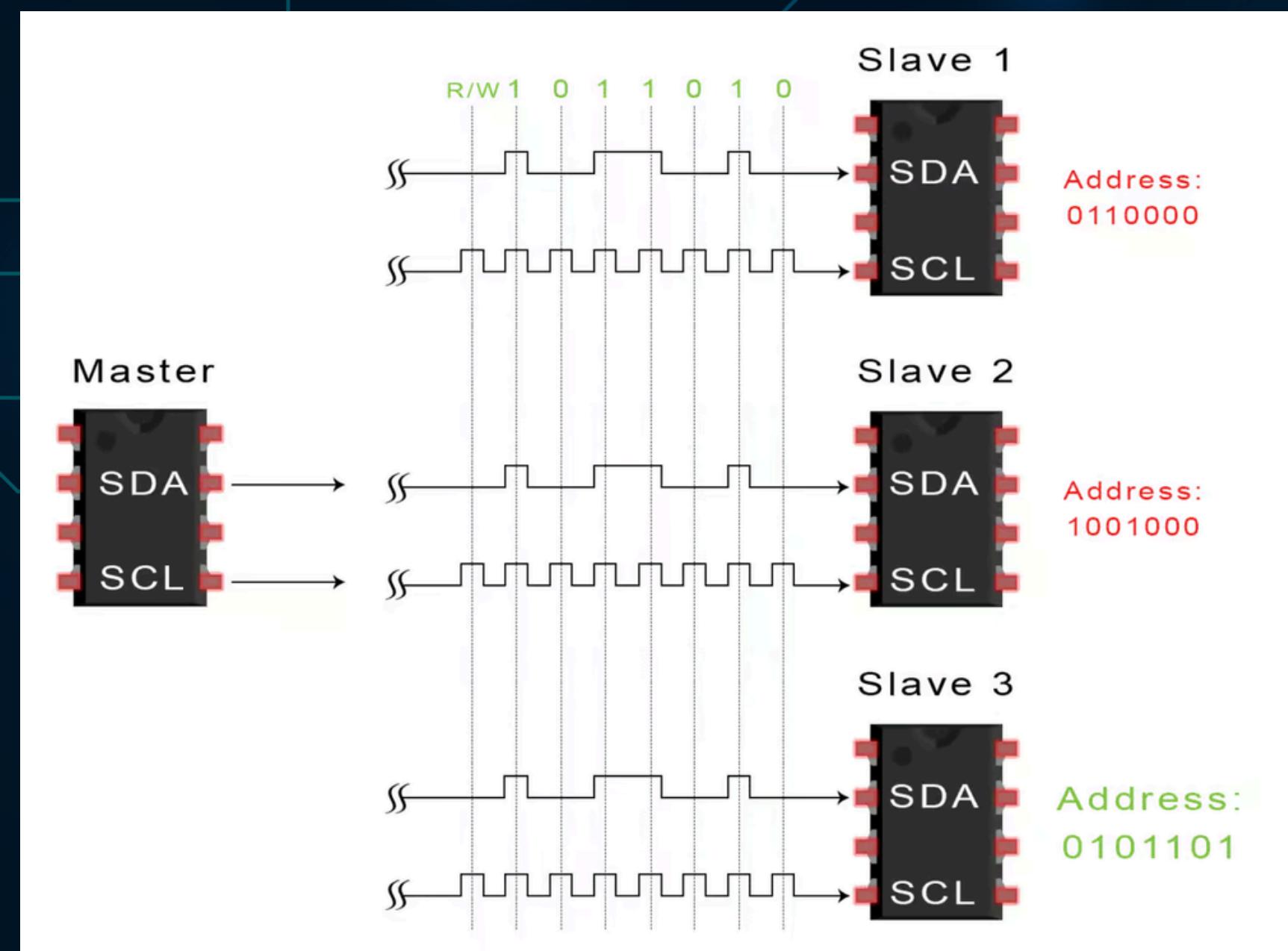
SPI

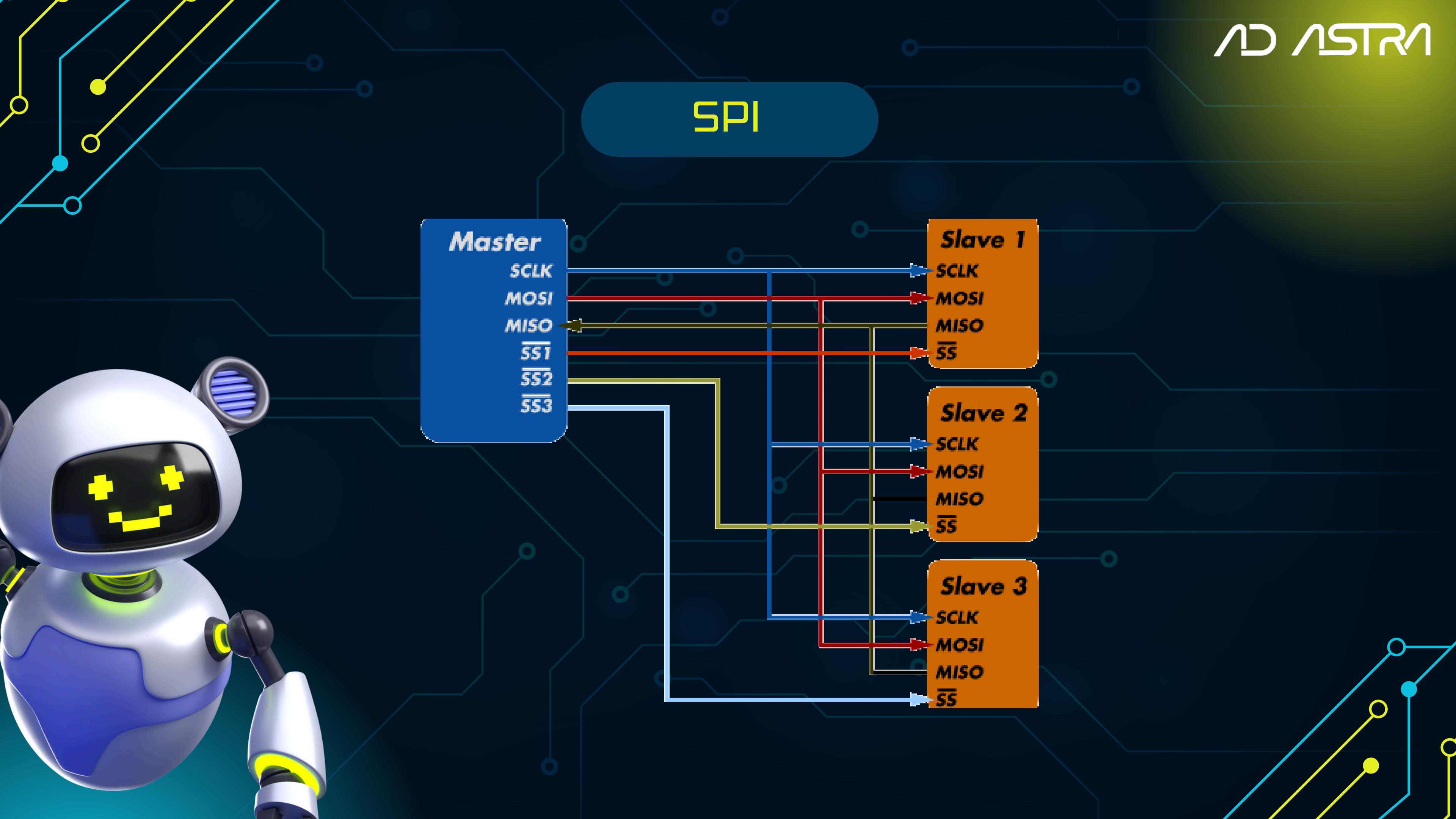


UART

Serial communication







ROBOTICS FUNDAMENTALS

AD ASTRA



The robot interacts with the world via Sensors (Ultrasonic for distance, IR for line following, Lidar for mapping).

Sensing

The MCU processes sensor data and applies algorithms like PID (Proportional-Integral-Derivative) for smooth motion.

Perception & Logic

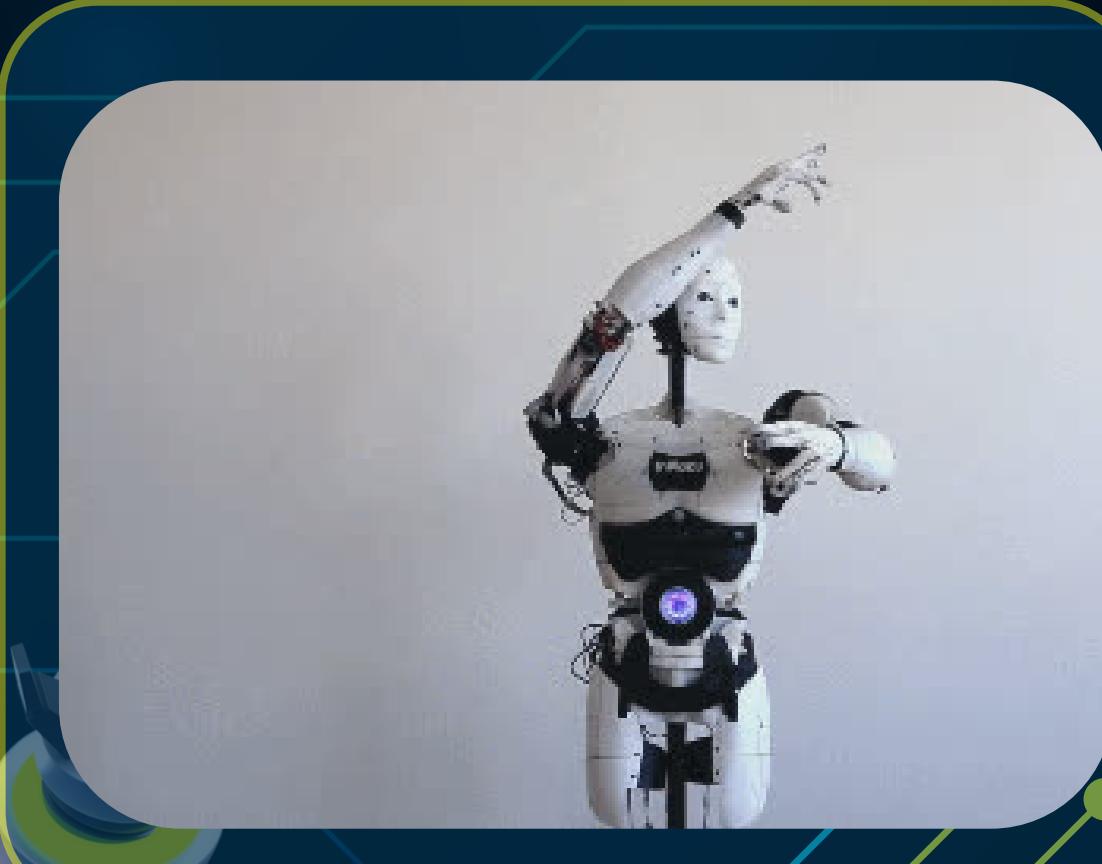
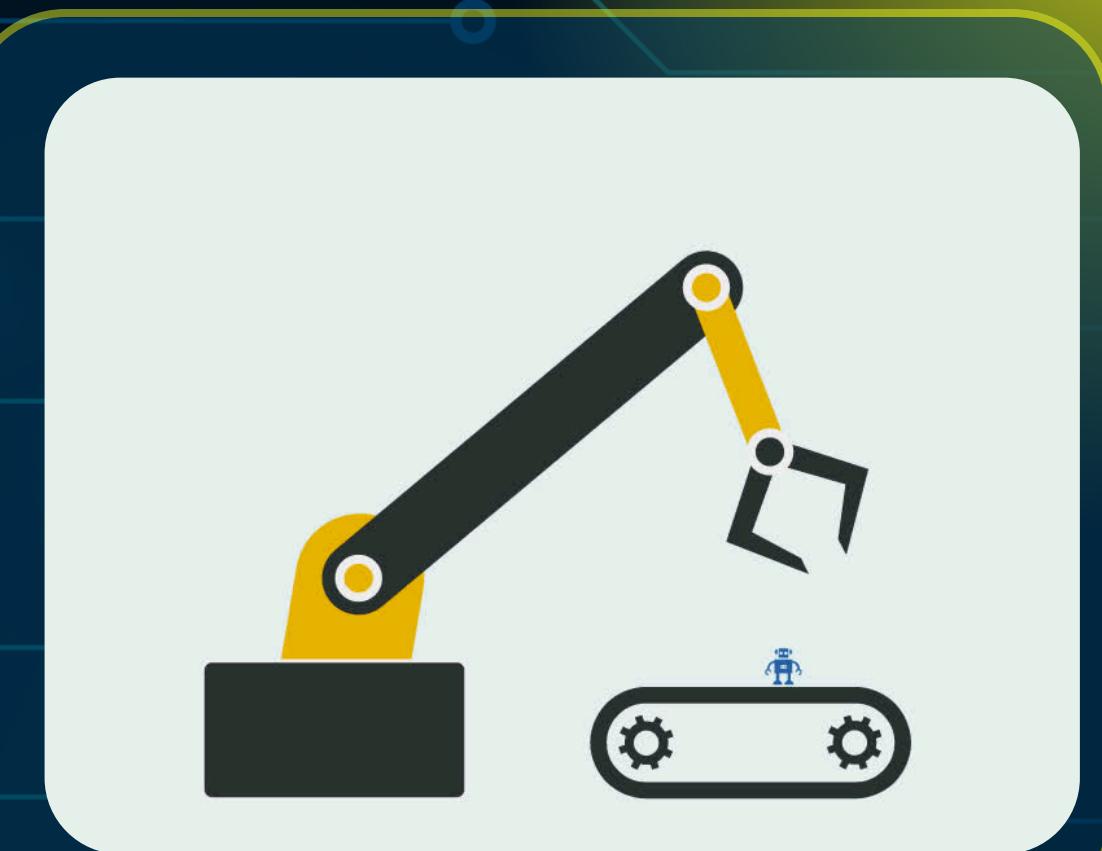
Converting electrical energy into physical motion via DC Motors, Servo Motors, or Steppers.

Actuation

The number of independent ways a robot can move in 3D space.

Degrees of Freedom (DOF)

AD ASTRA

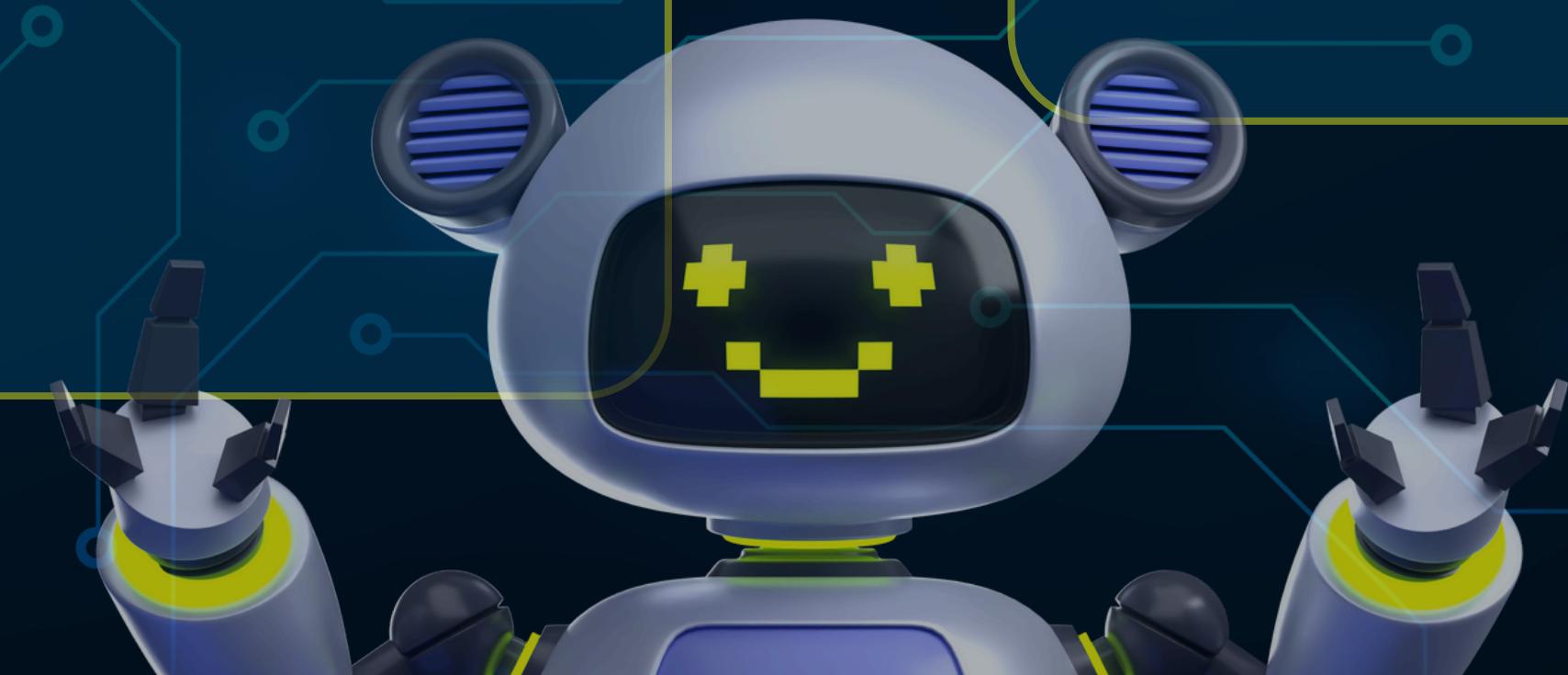
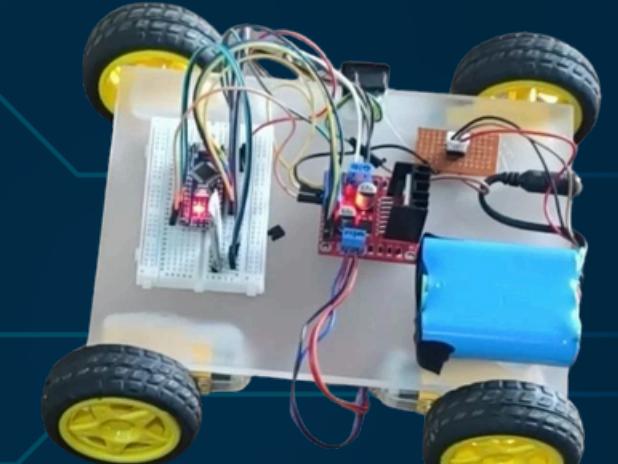
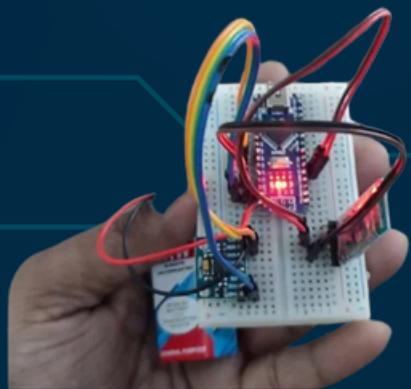


GESTURE BASED ROVER

ESP-NOW Architecture

Using two ESP32 units: One as a Transmitter (Hand Glove) and one as a Receiver (Rover Chassis).

- MPU6050: Gyro + Accelerometer for tilt sensing.
- Low Latency: ESP-NOW connects directly without a router.
- Real-time: 1ms response time for motor control.

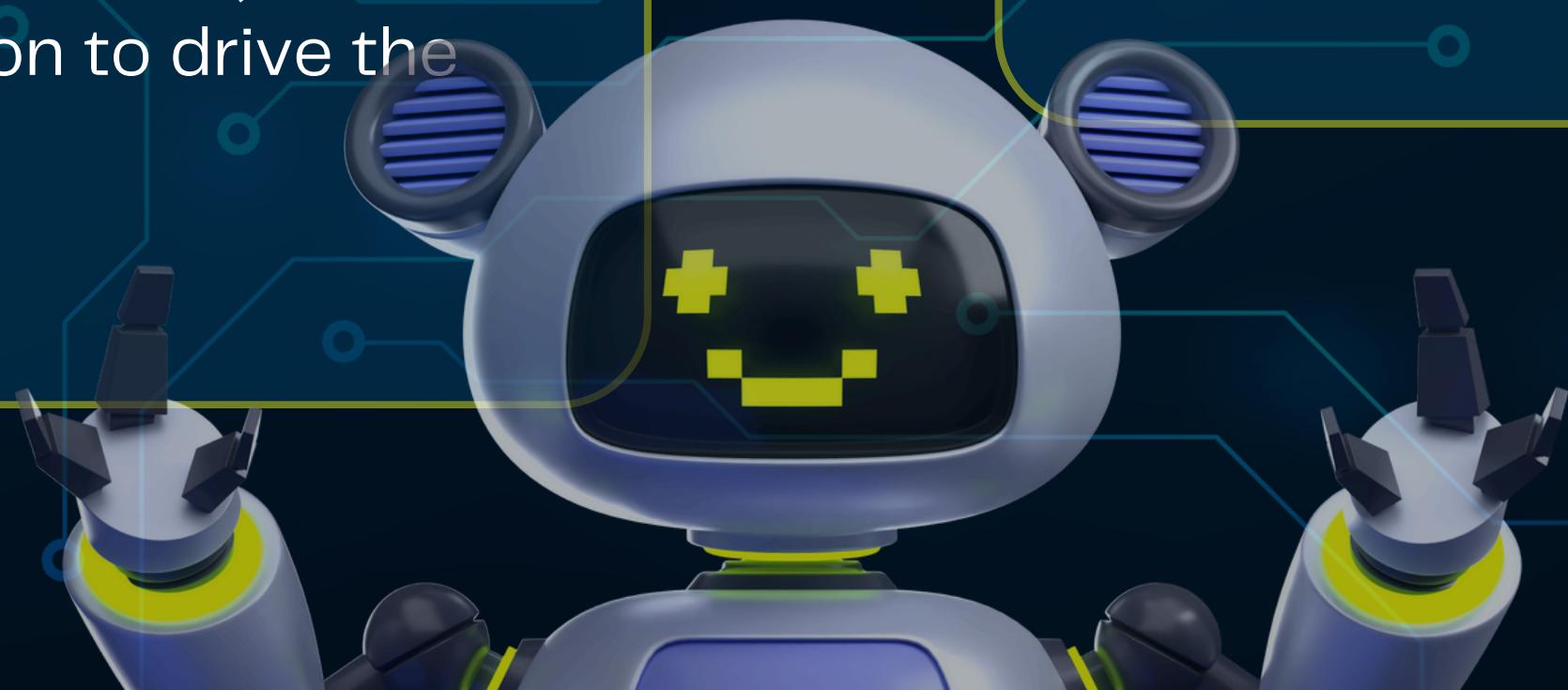
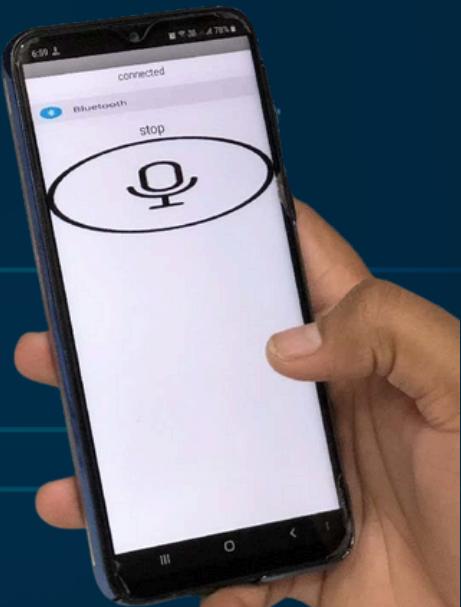
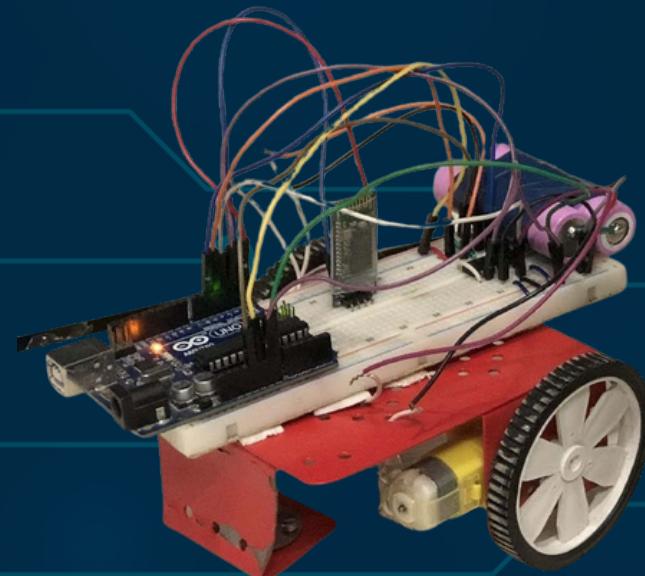


VOICE CONTROL ROVER

NLP to Hardware

This project uses a Smartphone as the primary interface. Voice commands are converted to text via Google/Siri speech-to-text APIs.

The text strings are transmitted via Bluetooth (BLE) to the ESP32, which parses the string (e.g., "Move Forward") and executes a specific C++ function to drive the motors.



AD ASTRA

THANK YOU

