Navigation and Communication for UGV/UAV

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Introduction

- This thesis titled "Navigation and communication for UGV/UAV, consists of two parts:
  - The navigation part of this thesis includes utilization of various controllers to implement applications on UGV/UAV hardware.
  - The communication part explores the use of SATCOM and NBIoT for communicating with UAV.
- UGV and UAV kits are ideal low-cost prototype systems for testing software before scaling it up and putting it on a real ground vehicle or a more complicated UAV system.

UGV kit hardware

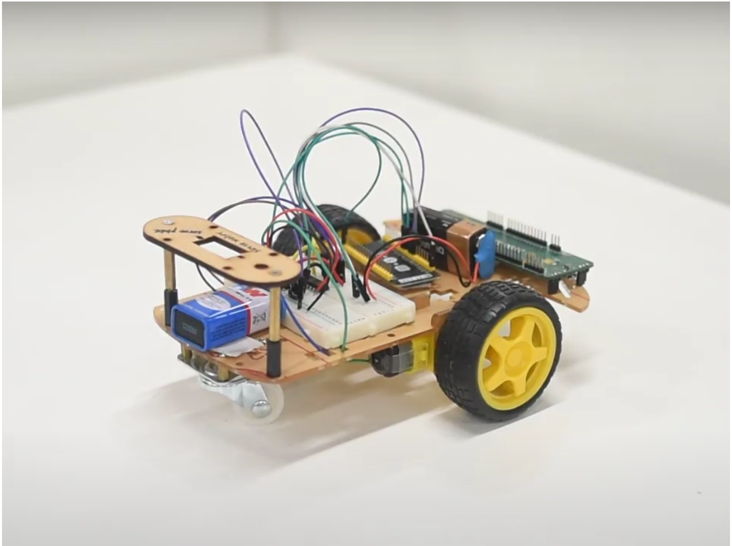


Figure: UGV kit hardware

UAV kit hardware

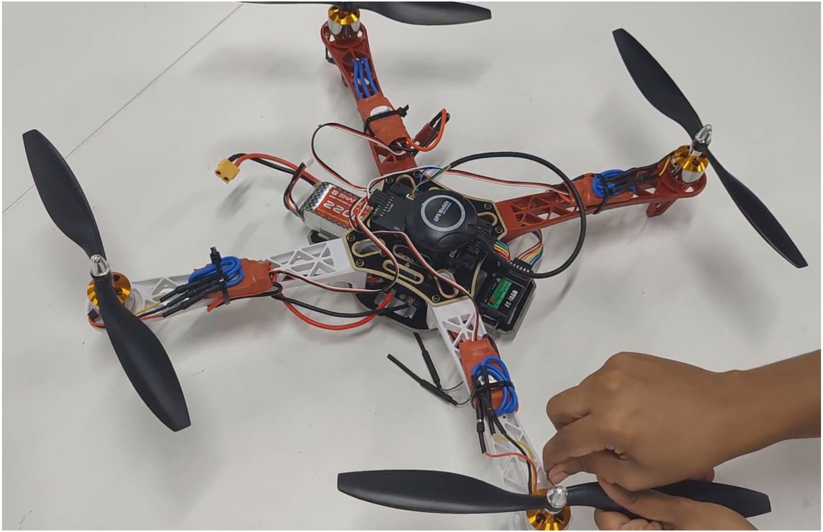


Figure: UAV kit hardware

Controllers

Parameters	Arduino Uno	Raspberry Pi 3B	ESP-32
Processor	ATMega328P	Quad-core Broadcom BCM2837 (4×Cortex-A53)	Xtensa Dual-Core 32-bit LX6 with 600 DMIPS
GPU	-	Broadcom VideoCore IV @ 250 MHz	-
Operating voltage	5V	5V	3.3V
Clock speed	16 MHz	1.2GHz	26 MHz – 52 MHz
System memory	2kB	1 GB	<45kB
Flash memory	32 kB	-	up to 128MB
EEPROM	1 kB	-	-
Communication supported	IEEE 802.11 b/g/n Bluetooth via Shield	IEEE 802.11 b/g/n Bluetooth, Ethernet Serial	IEEE 802.11 b/g/n
Development environments	Arduino IDE	Any linux compatible IDE	Arduino IDE, Lua Loader
Programming language	Embedded C, C++	Python, C, C++, Java, Scratch, Ruby	Embedded C, C++
I/O Connectivity	SPI I2C UART GPIO	SPI DSI UART SDIOCSI GPIO	UART, GPIO

Table: Comparison between Arduino Uno, Raspberry Pi 3B and ESP-32

Controllers (Vaman)

- On-board dual processor (ARM + FPGA)
- On-board WiFi/BT/BLE connectivity with ESP32
- μSD card support
- On-board inertial measurement unit
- On-board BMO055 smart fusion sensor
- On-board DPS310 provides pressure, humidity and temperature monitoring

Figure: Vaman - Pygmy BB4

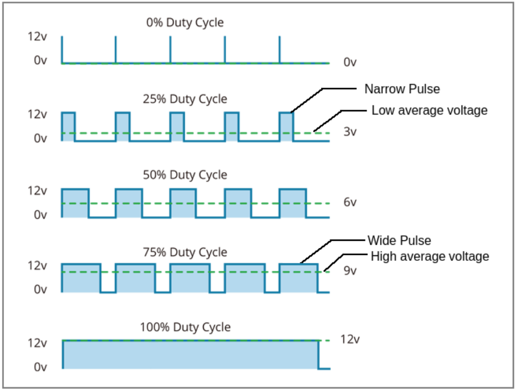
Motor control using PWM

- A pulse width modulation speed control system works by sending a series of "ON-OFF" pulses to the motor. The frequency of square wave is kept constant while varying the duty cycle (the fraction of time that the output voltage is "ON" compared to when it is "OFF").
- By changing the width of the ON duration, one can control the average DC voltage applied to the motor. The below equation (1) gives the relation between the Duty cycle (D) and the average voltage:

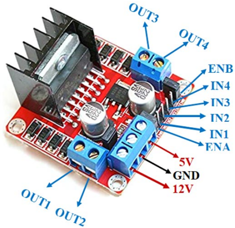
$$V_{dc} = \frac{1}{T}\int_0^T v_{PWM}(t)\,dt \tag{1}$$

$$\begin{aligned} V_{dc} &= \frac{1}{T}\left(\int_0^{DT} v_{\text{max}}\,dt + \int_{DT}^{T} v_{\text{min}}\,dt\right) \\ &= \frac{1}{T}\left(D \cdot T \cdot v_{\text{max}} + T\,(1 - D)\,v_{\text{min}}\right) \\ &= D \cdot v_{\text{max}} + (1 - D)\,v_{\text{min}} \end{aligned}$$

Motor control using PWM (Continued)



(a) PWM speed control



(b) Dual motor driver module (L298N)

ESP32 Based Applications-1

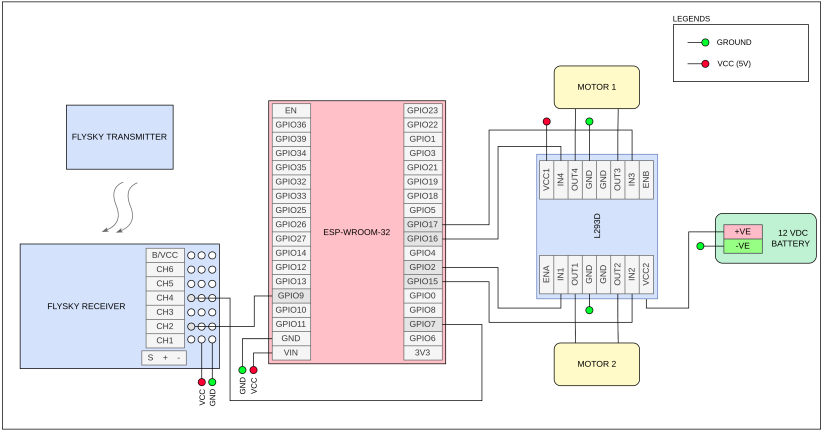


Figure: UGV Navigation using Fly-sky transmitter & receiver (ESP32)

ESP32 Based Applications-2

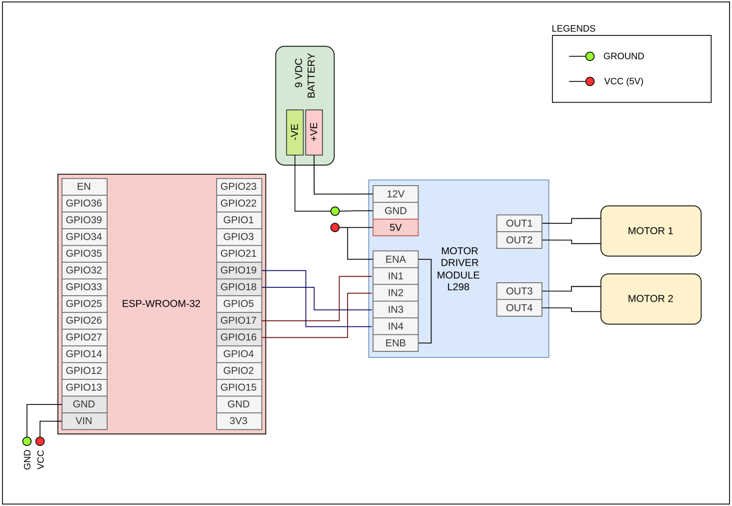


Figure: UGV Navigation using Android phone (ESP32)(Manual and Speech)

ESP32 Based Applications-3

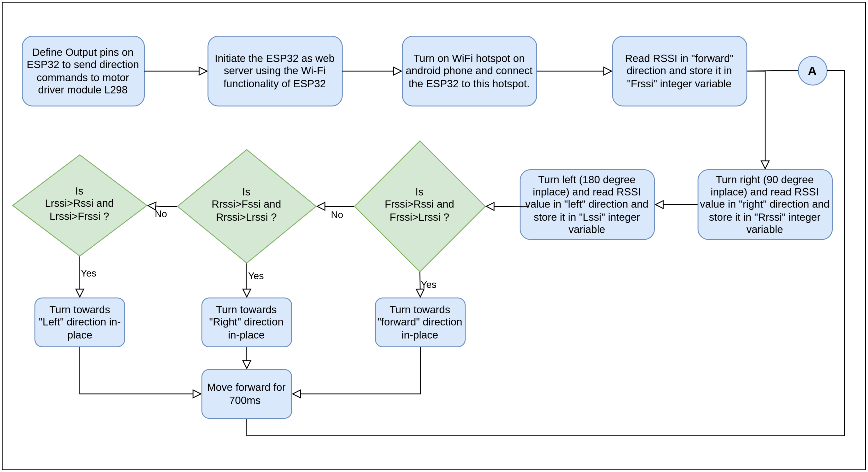


Figure: UGV beacon tracking

ESP32 Based Applications-4

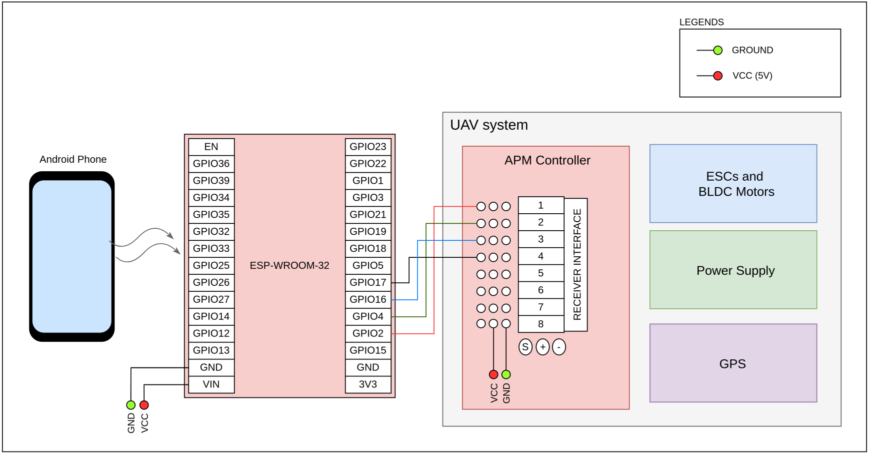


Figure: UAV Navigation using ESP32 and Android phone

Vaman Based Applications-1

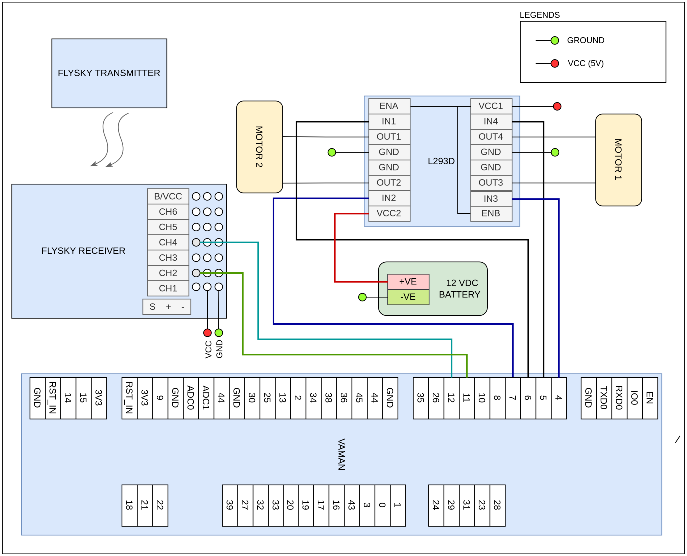


Figure: UGV Navigation using Fly-sky transmitter & receiver (V…)

Vaman Based Applications-2

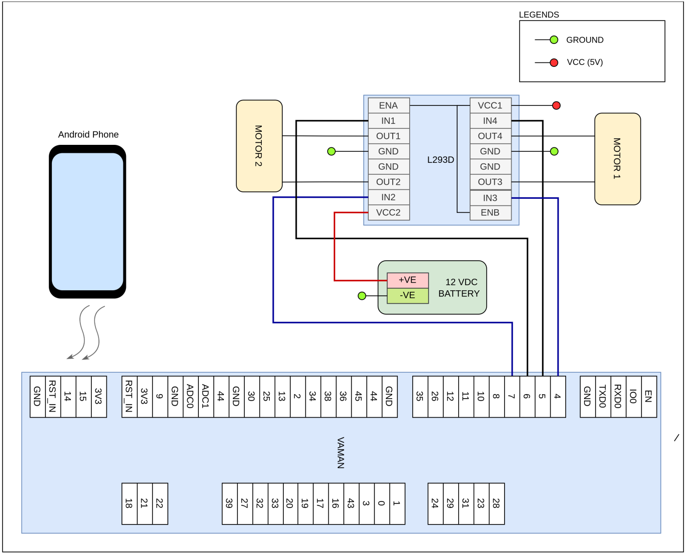


Figure: UGV Navigation using Android phone (Vaman)

SATCOM for UAV Communication

- When the cricket ball travel through the air towards the batsman, the air flow around the ball can be **laminar** or **turbulent**.

Conclusion and Future Directions