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يُونُسُ بَرَسِيَّتِي إِسْلَامُ، إِنْتَارَا بَغْسِيَا مِلْدِسِيَا
Garden of Knowledge and Virtue

KULLIYAH OF ENGINEERING
DEPARTMENT OF MECHATRONICS

MCTE 4362
ROBOTICS HARDWARE SYSTEMS

PROJECT:
VERSATILE ANIMAL INSPIRED SERVICE ROBOT THAT CAN
MOVE REMOTELY ON LAND, AIR AND WATER

Group G: AlTerraR Search and Rescue (Spider)

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EXECUTIVE SUMMARY

This project discusses a robotic design inspired by spiders, dragonflies and water striders. The robot has the ability to operate on land, air and water (Figure 1). It is designed to perform remote exploration and rescue tasks in any environment. For on land operations, The robot is equipped with 4 legs that are attached to servo motors for motion. Meanwhile for on Air operations, the design consists of two drone propellers mimicking dualcopters. As for on water operations, the legs of the robot are connected to floats to provide buoyancy.

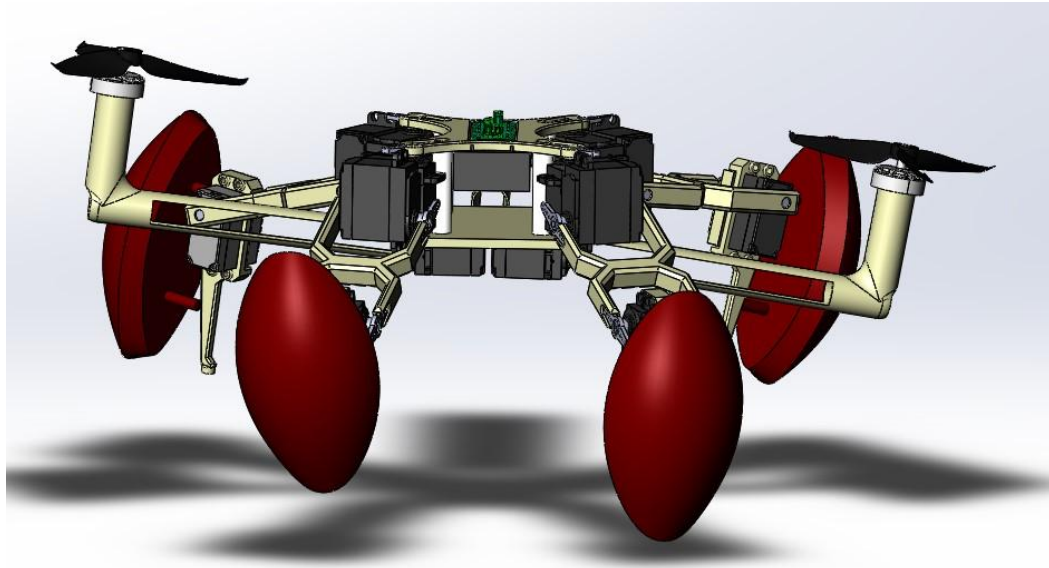


Figure 1: AlTerraR search and rescue robot

This report provides a detailed architecture illustrating the robot design and working principle. The 6 components of robotic systems are provided to explain the conceptual design. The report also includes safety considerations and factors in order to protect the robot under rough environments.

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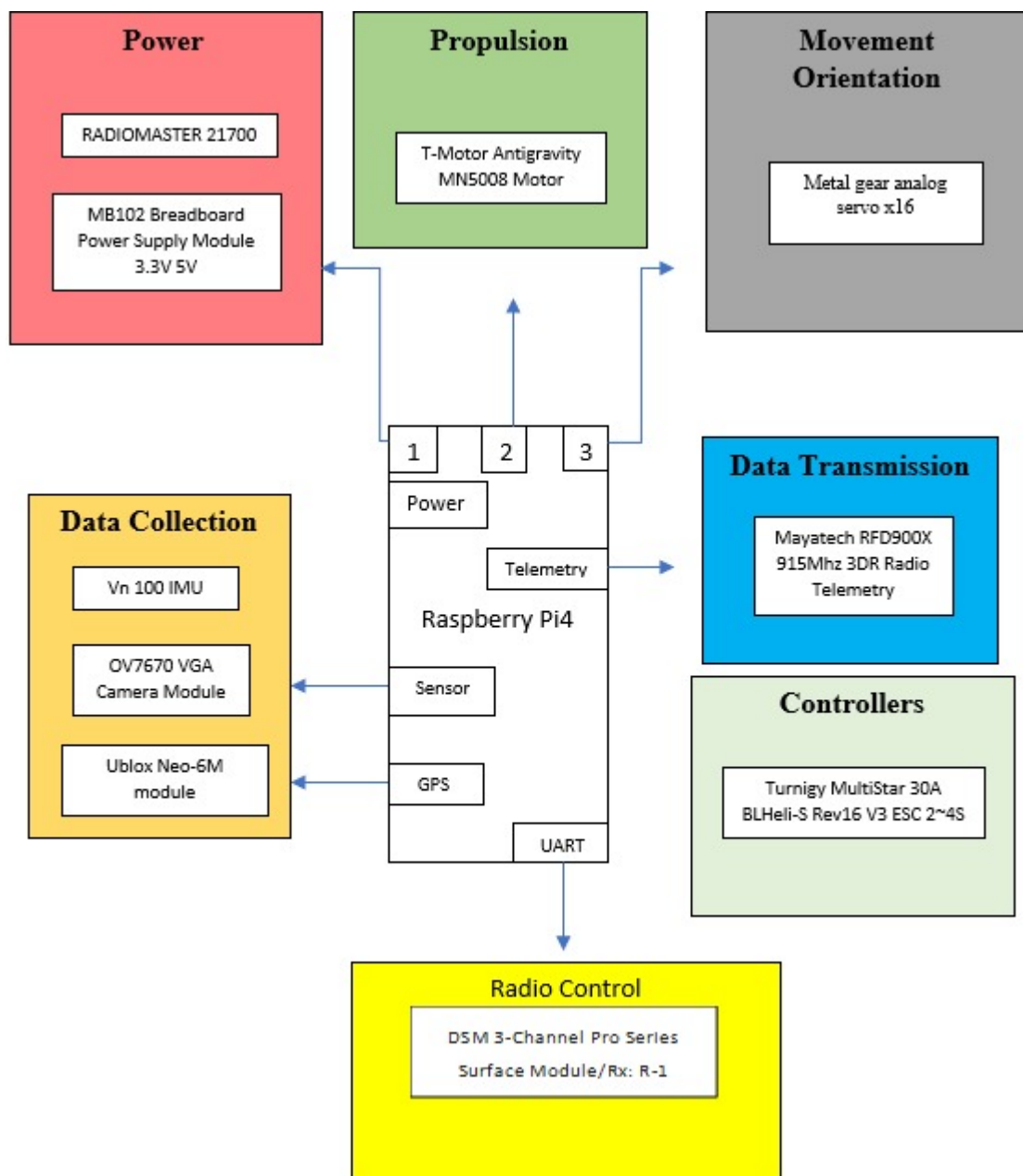
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DESIGN PROBLEM AND OBJECTIVES

- To explore dangerous areas to man regardless of the terrain
- To be able to operate from a distance

DETAILED DESIGN DOCUMENTATION

a) System Architecture



b) Components specifications

I- Mechanical Design

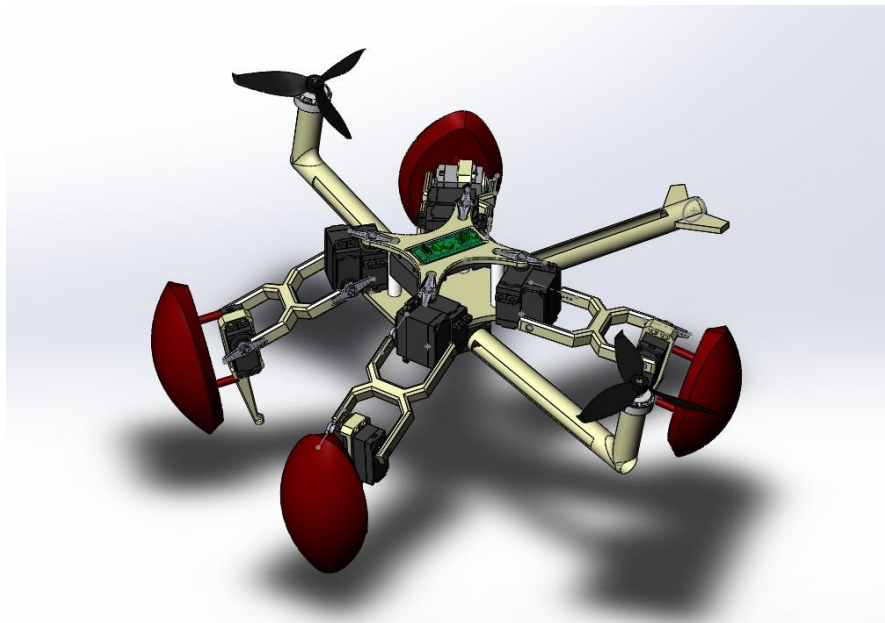


Figure 2: Design in land and air mode

The first mode of the robot enables land and air operations. The 4 legs of the robot are inspired by spiders to provide efficient on land movement. Meanwhile, two wings are attached to the robot sides with propellers connected to their ends designed for flight mode. Additionally, the body of the robot has a tale to help balance the robot while flying. The material of the frame and propellers is carbon fibre, providing the robot with light weight, more strength and rust resistance.

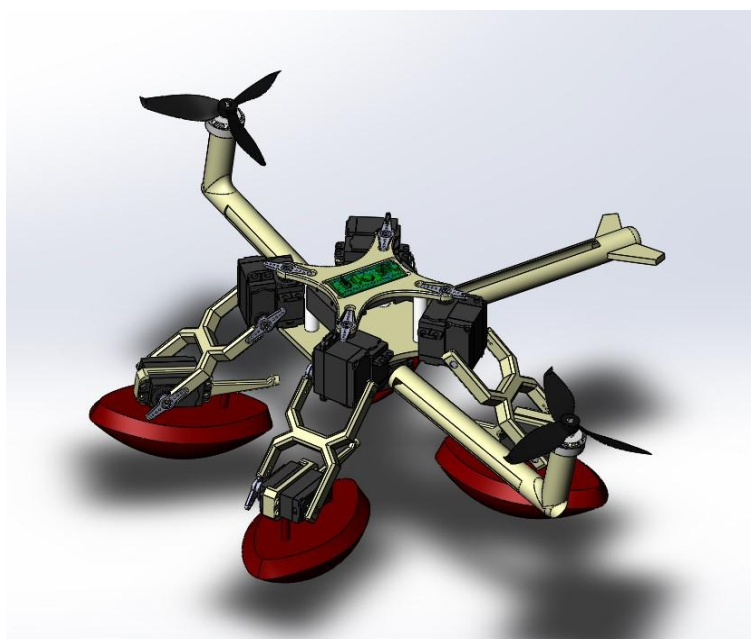
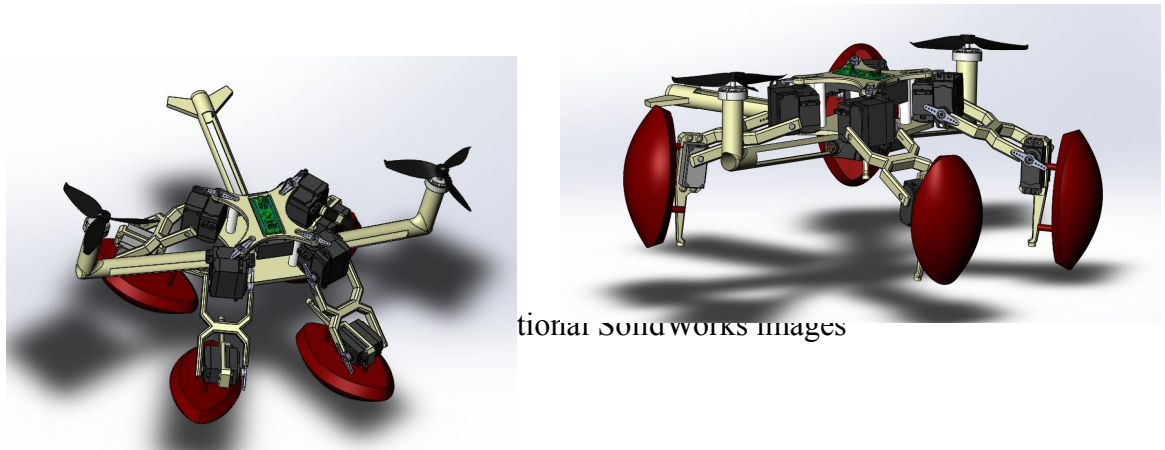


Figure 3: Design in water mode

For on water mode, the legs of the robot folds to create a base that utilises buoyancy to allow the robot to float on water. Moreover, the wings of the robot are directly connected to servo motors which can rotate propellers to a position where the system can move on water. The bouyants are made of plastic to maintain low weight and provide collision protection.



II- Actuator

The robot consists of 14 servo motors responsible for moving the 4 legs and rotating the wings. The servo used is FeeTech FS5109M chosen because of its torque and size which are suitable for this system (Figure 5).



Figure 5: FeeTech FS5109M servo motor

Specifications:

Operating Speed: 0.16sec/60degree (6V)

Stall Torque: 10.2kg.cm/141.9oz.in(6V)

Operating Voltage: 4.8V~6V

Control System: Analog

Direction: CCW

Operating Angle: 180degree

Required Pulse: 500us-2500us

Bearing Type: 2BB

Gear Type: Metal

Motor Type: Carbon

Connector Wire Length: 30 cm

Furthermore, T-Motor Antigravity MN5008 drone Motor (Figure 6) is used to rotate the propeller for flight and on water motion. This particular motor can provide sufficient speed and thrust to left the entire robot.



Figure 6: T-Motor Antigravity MN5008 drone Motor

Specifications:

Motor size: $\varnothing 55.6 \times 32$ mm

Configuration: 24N28P

Shaft Diameter: 6mm

Lead Cable: 80mm

Idle Current: 0.4A

Max. Power : 720W

Internal Resistance: 720m Ω

Rated Voltage: 6-12V

Peak Current: 15A

Prop Recommendation: P17-18"

III- Navigation System and Controller



Neo-6M

Update rate: 1Hz (Default), 5Hz (Max)

External GPS antenna

With MicroSD Interface for data storage

Onboard 3V supercapacitor as a backup battery

Onboard 3.3v regulator

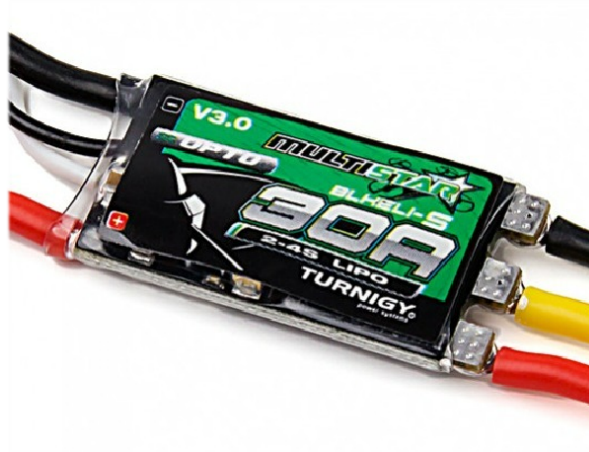
3.3V and 5V logic level compatible

Power and fix indicator LEDs

Reset Button

Weight: 23g, 55g (GPS antenna + cable)

Baud rate: 9600



Turnigy MultiStar 30A BLHeli-S Rev16

- Small and lightweight (only 9.1g)
- S code for superior performance
- Smooth and linear control
- Oneshot125 for rapid throttle response
- Compatible with DShot150 and DShot300 firmware
- Regenerative braking
- Active freewheeling
- Beacon functionality
- Stalled motor protection
- Throttle signal loss protection
- Safe power-on (throttle lockout)
- Thermal protection



Raspberry Pi 4

Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz

1GB, 2GB, 4GB or 8GB LPDDR4-3200 SDRAM (depending on model)

2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE

Gigabit Ethernet

2 USB 3.0 ports; 2 USB 2.0 ports.

Raspberry Pi standard 40 pin GPIO header (fully backwards compatible with previous boards)

2 × micro-HDMI ports (up to 4kp60 supported)

2-lane MIPI DSI display port

2-lane MIPI CSI camera port

4-pole stereo audio and composite video port

H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)

OpenGL ES 3.1, Vulkan 1.0

Micro-SD card slot for loading operating system and data storage

5V DC via USB-C connector (minimum 3A*)

5V DC via GPIO header (minimum 3A*)

Power over Ethernet (PoE) enabled (requires separate PoE HAT)

Operating temperature: 0 – 50 degrees C ambient

IV- Data Collection



VN-100

VectorNav proprietary AHRS

VectorNav Processing Engine (VPE)

Real-time gyro bias tracking and compensation
Hard/Soft Iron Compensation
Real-time and delayed heave estimation
Coning and sculling integrals (ΔV 's, $\Delta \theta$'s)
Data output format: ASCII (VectorNav), Binary (VectorNav)
World Magnetic & Gravity Reference Models
VectorNav Control Center GUI
ITAR-Free



OV7670

Single power source: 3.3V, onboard regulator
High sensitivity suitable for illumination applications
Standard SCCB interface compatible with I2C interface
Photosensitive array: 640x480 pixel
IO Voltage: 2.5V to 3.0V (internal LDO for nuclear power 1.8V)
Power operation: 60mW/15fpsVGAYUV
Output Formats: YUV/YCbCr4: 2:2 RGB565/555/444 GRB4: 2:2 Raw RGB Data
Optical size: 1/6 "
FOV: 25 °
Maximum Zhen rate: 30fps VGA
Sensitivity: 1.3V / (Lux-sec)
SNR: 46 dB

Dynamic range: 52 dB

View Mode: Progressive

Electronic Exposure: 1 line to 510 line

Pixel Size: 3.6 μ m x 3.6 μ m

V- Data Transmission



Mayatech RFD900X 915Mhz 3DR Radio Telemetry Modem Module

Communication rate: 4,8,16,19,24,32,48,64,96,128,192 and 250 kbps.

Transmitting power: 0 to 30 dBm, 1 dBm stepping adjustable.

Power supply voltage rated 5V minimum 4V maximum 5.5V;

Emission current: 1A (maximum power mode);

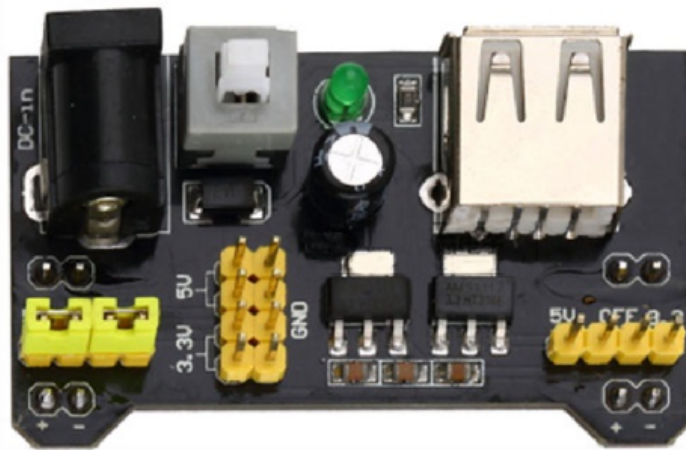
Acceptance current: 60 mA;

Working temperature: – 40 to + 85 degrees Celsius;

Dimensions: 32.5 mm * 53 mm * 9.5 mm

Weight: 23g

VI- Power Management



MB-102 Breadboard Power Supply Module

Input voltage: DC 6.5-12V or powered by USB

Output voltage: 5V, 3.3V

Maximum Output Current: 700mA



RADIOMASTER 21700

Item: 21700 5000mAh Battery

Capacity: 5000mAh

Watt Hours: 37wh

Voltage: 7.4V

Cells: 2 x 21700 Li-ion 3.7V 18.5Wh

Connector: JST-XH and XT30

Charge current: Max 2amp



SAFETY CONSIDERATION

- Buoyant pads attached to the legs of the robot help protect against impact
- Components are contained and waterproofed in an acrylic shell to avoid water damage
- Robot is built with a master switch that cuts power to all components in case of emergency
- Parts can be individually replaced if a component or part of the body is damaged

CONCLUSION

To conclude this product is something that has not yet been seen by the world since it can be operated on three terrains. Therefore the operation of search and rescue can be conducted with much ease by using this robot.