Functional Specification

Project Title: RAMP

Alanna Carton

&

Ronan Barker

Functional Specification Contents

Table of contents

1. Introduction

1.1 Overview

With today's architecture and engineering endeavours, we find it necessary to inspect and maintain these constructions which sometimes involves operating in sometimes quite inhospitable conditions. Sometimes the need arises to inspect/search places humans cannot operate safely and effectively. These conditions could range from anywhere between wind turbine or bridge inspections to mapping places such as pipelines or archaeological discoveries.

This system will utilise real time image processing to recognise any condition/object which the unit has been trained to recognise. The unit will then alert the operator to its findings as they arise relaying the onboard sensor data and video data to the user in order to highlight the location and object found. This allows the operator to redirect the unit back to a previously recognised object for further inspection either by manual override or by sending a repeat command to the unit.

1.2 Glossary

At the edge: Calculations carried out in the devices location rather than being cloud based or data transferred via network for processing.

2. General Description

2.1 Product / System Functions

The system is a data collection and object recognition device utilising a neural network to classify image data which provides for multiple uses such as search or inspection operations.

This version will be mounted to a miniature tank chassis for mobility purposes however the principals employed can be used in various scenarios and adapted or scaled for different requirements.

1. Object search using neural network object recognition and classification.
2. Provide real time telemetric data to the user such as GPS positioning.
3. Live video feed to user interface.
4. Override function for manual control of the unit
5. User alert highlighting the GPS position of the object

2.2 User Characteristics and Objectives

This unit is aimed at users who require the ability to visually inspect or carry out object recognition in difficult places and circumstances. By remotely sending video and telemetric data to the user who could remotely view the data or operate the unit via a control device or pre-programed inspection patterns.
A joystick type control will allow the user to manoeuver the vehicle while viewing the camera and telemetry data over a WiFi connection with the unit. In the background the images will be processed using machine learning through the neural compute stick to recognise/classify objects and the user will be alerted. The result of this object detection will be returned to the user.

The users can expect a small vehicle with mounted sensors and cameras for data collection. The unit is intuitive and easy to use and understand. The data collected will then be visually represented to the user with any findings. Data analytics to be quick, efficient and objects to be correctly identified and classified.

2.3 Operational Scenarios

2.3.1

Use Case 1 - Search for Object

USE CASE 1	Search For object.	
Goal in Context	User searches for object.	
Scope & Level	User, High.	
Preconditions	System is trained to recognise the object. User has set search parameters.	
Success End Condition	User is alerted to the object's GPS location and views live video of the unit camera view.	
Failed End Condition	Object not recognised.	
Primary, Secondary Actors	User, None.	
Trigger	User activates search.	
DESCRIPTION	**Step**	**Action**
	1	User opens application.
	2	User selects search parameters.
	3	User activates search.
	4	User receives notification of object recognition.
	5	User views live video from unit.
EXTENSIONS	**Step**	**Branching Action**
	2.1	User selects one of the many search parameters. 2.1.a If no parameter is selected then system continues with no object searching.
	3.1	Parameter not set notification.

2.3.2

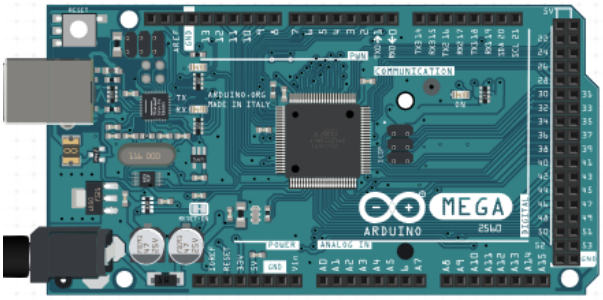
Use Case 2 - Manual control of vehicle

USE CASE 1	Controlling the vehicle	
Goal in Context	User controls the vehicle movement	
Scope & Level	User, High.	
Preconditions	User is logged in to wifi system and has a directional control device	
Success End Condition	User is controlling the movements of the device	
Failed End Condition	Failure to control the movement of the device	
Primary, Secondary Actors	User, None.	
Trigger	User selects manual control of the device	
DESCRIPTION	**Step**	**Action**
	1	User opens the application and selects manual control of the device
	2	User then configures and connects directional control device
	3	User uses directional control device
	4	The device moves as the user directs it to.

2.4 Constraints

Module: Arduino Microcontroller: Is an open-source electronics platform which utilises I²C and SPI communication protocols to transmit and receive data to serially connected devices.
Difficulty: Gain knowledge in programming in C++ and learn I²C and SPI protocols. Coding for Interfacing with the microcontroller.

Arduino Nano V3



Arduino Mega 2560

Module: nRF24L01+ Is a single chip radio transceiver for the world wide 2.4 - 2.5 GHz ISM
band.
Difficulty: Gain knowledge in nRF24L01+ datagram protocols and coding.

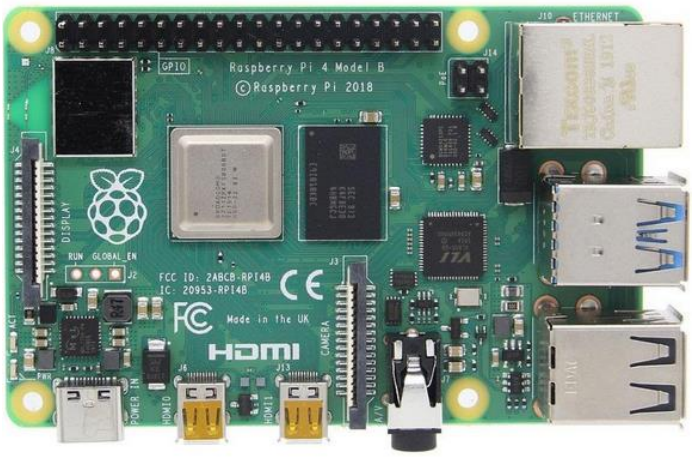
nRF24L01+

Module: Intel Movidius Neural Compute stick: Allows for deep neural networks at low power. Allows for neural networks on the Raspberry Pi
Difficulty: Gain knowledge about the Neural Compute stick, Use it to build the network and learning to train a dataset

Neural Compute stick 2

Module: Raspberry Pi 4: Uses a Broadcom BCM2711 SoC with a 1.5 GHz 64-bit quad-core ARM Cortex-A72 processor, **4GB** LPDDR4-3200 SDRAM, 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless with Bluetooth 5.0, BLE.

Difficulty: Interfacing between the Pi and the Arduino microcontroller



Raspberry Pi 4 Model B

Power constraints: As the unit itself is mobile a power source will need to be used therefore some electronic engineering knowledge will be needed to learn about battery packs to not damage the logic voltage sensitive equipment.

Processing constraints: As we are using a Raspberry and numerous Arduinos we are limited to their small supply of processing power which will not be enough to run large programs. As a result of this we are using the Neural Compute stick to bear the brunt of the image processing.

Size and weight are not a factor as the unit should way less than a kilogram easily carried by commercial drones or controlled vehicles. This unit is a development unit only

3. Functional Requirements

3.1 Object Recognition

- **Description -** Object Recognition.
- **Criticality -** The system will be required to recognise objects and to relay the objects GPS location.
- **Technical issues -** Describes any design or implementation issues involved in satisfying this requirement
- **Dependencies with other requirements –** Camera system

3.2 Camera System

- **Description -** Camera.
- **Criticality -** The camera is required for the systems image recognition via the neural network, as well as allowing the user to see the output of the camera.
- **Technical issues -** Wifi communication with Raspberry Pi for live video transfer. **Dependencies with other requirements -**.Object Recognition

3.3 Mobile Platform

- **Description -** Mobile platform.
- **Criticality -** The mobile platform is required to transport the camera and sensor array..
- **Technical issues -**. RF communication for user manual unit control and microcontroller interrupts.
- **Dependencies with other requirements –** Camera system, sensor array, Object recognition

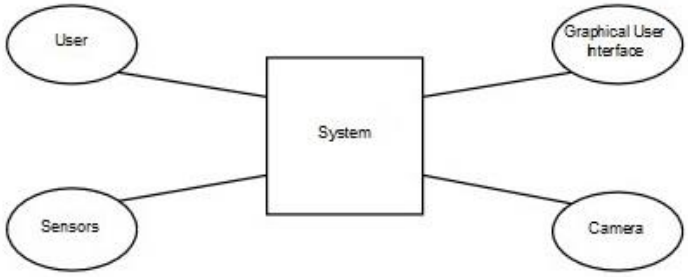
3.4 Sensor Array

- **Description -** Sensor array.
- **Criticality -** The sensor array is required for on board route decision making, object avoidance and to provide to the user updated Video and condition data such as GPS location information.
- **Technical issues -** Wifi communication with Raspberry Pi for live video transfer. RF communication for user manual unit control and interrupt. Microcontroller and I^2C and SPI communication protocols.
- **Dependencies with other requirements –** Mobile platform

4. System Architecture

4.1

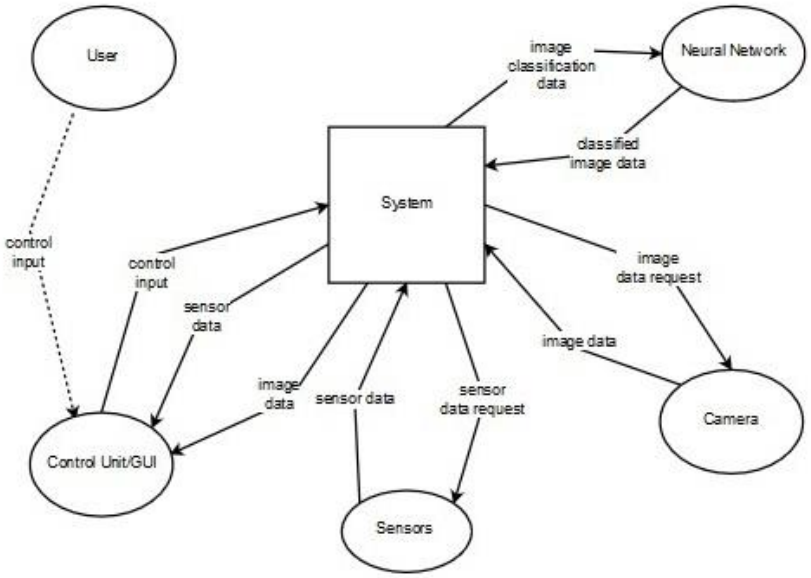
Concept Diagram



This diagram shows the basic idea of how our project components will interact.

4.2

Context Diagram

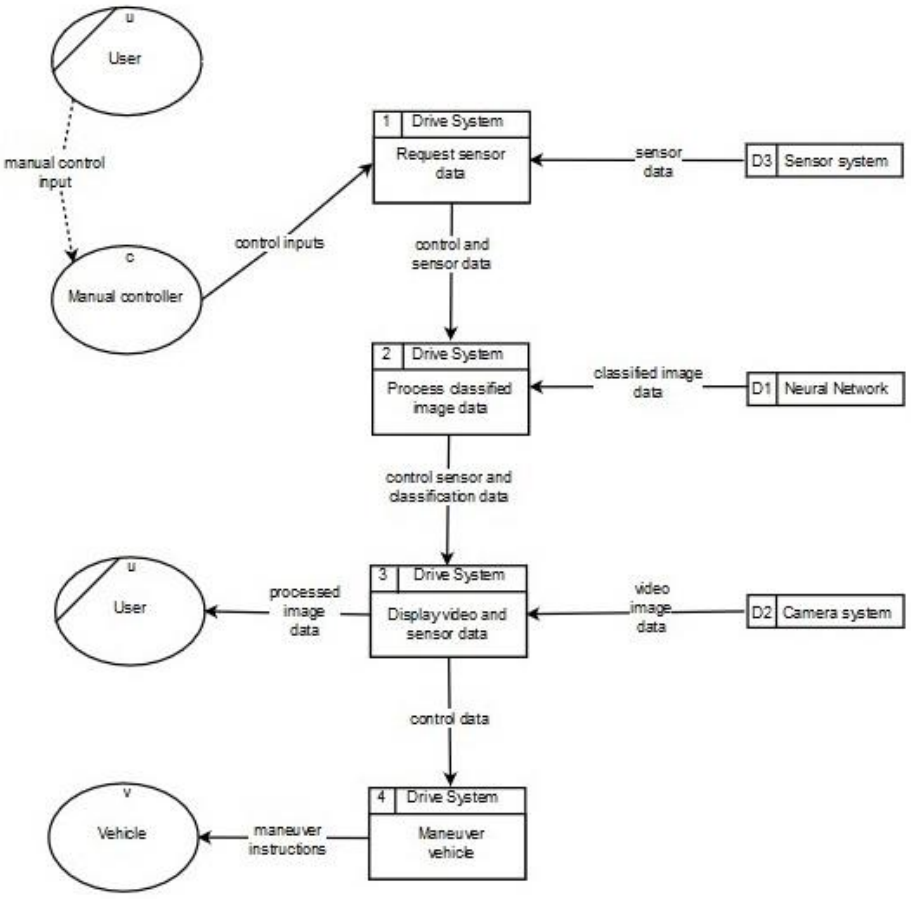


This diagram gives an overview of how the user and the system will interact. The user interacts with the control unit to receive information back from the system via wifi.
The system controls the various sensors, camera and the neural network on the neural compute stick 2. The system will request that data from the sensors and camera and then send it on to the user on the control unit.

5. High-Level Design

5.1

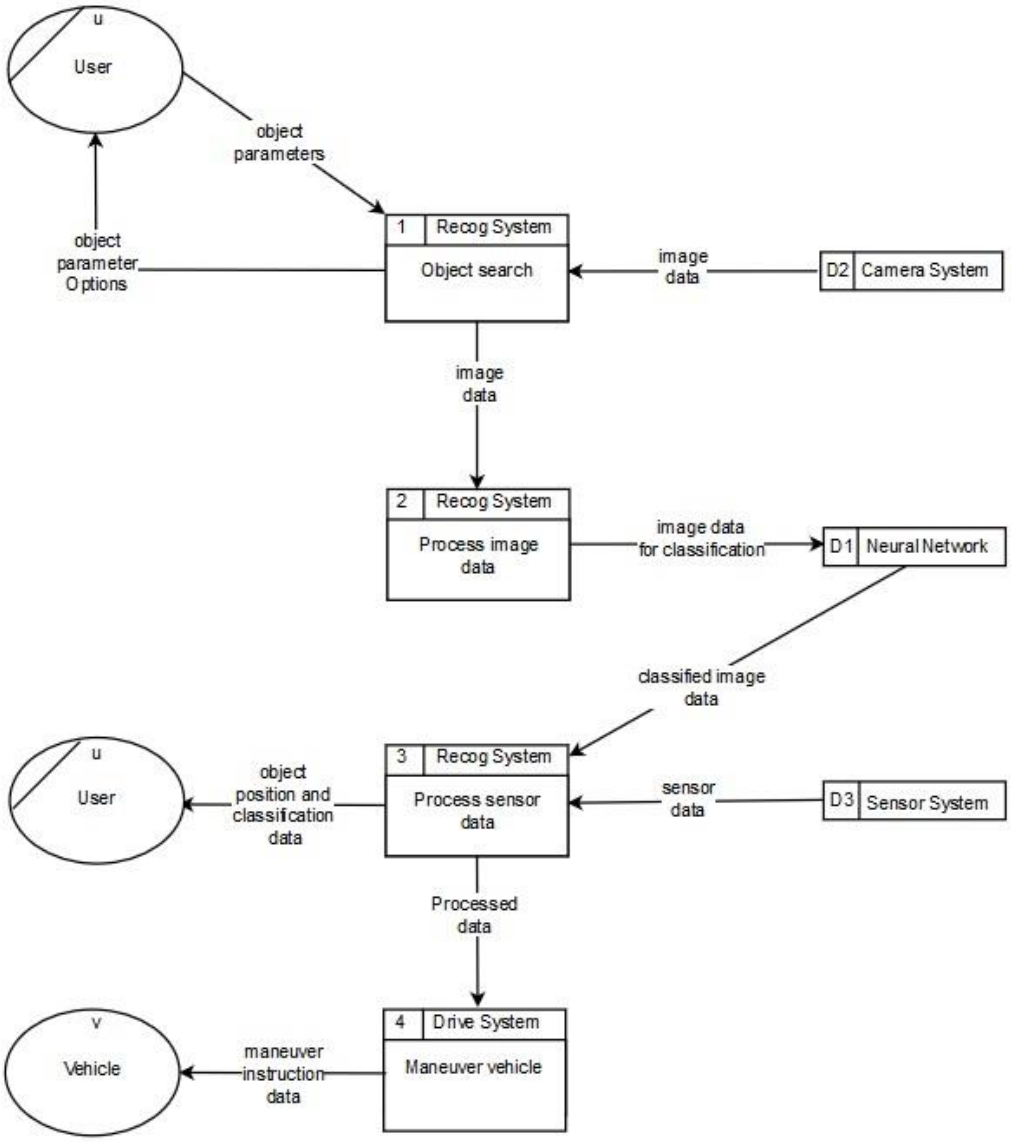
Data Flow Diagram
Manual Manoeuvring



This diagram shows the user controls the movement of the unit. The user controls the unit using the joystick. The unit requests data from the sensors. This data is sent to the unit. The unit will send the image data to the neural network to be processed. The unit then sends this processed image data to the user along with the sensor data.

5.2

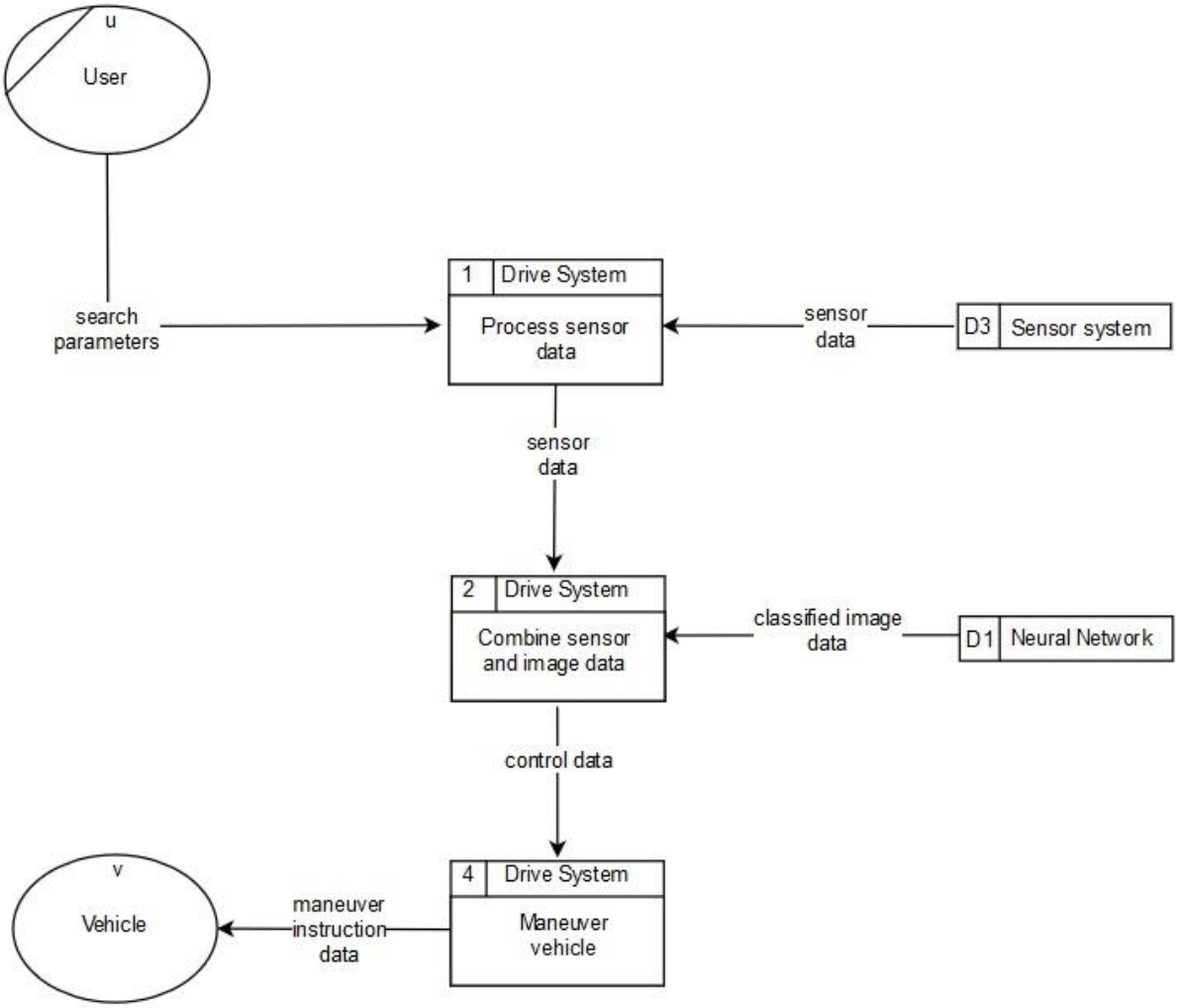
Data Flow Diagram
Object Recognition



This diagram shows how the object recognition will work in our system. The user selects the parameters of their search. The system receives the image data from the camera and sends it to the neural network. The neural network processes the image data and classifies any objects that are in the images. This processed and classified data is then returned to the user.

5.3

Data Flow Diagram
Vehicle Manoeuvring



The user enters and combining it with the neural network data search parameter and the unit carries out a search of the area processing the sensor data to send to the vehicle to manoeuvre.

6. Preliminary Schedule