Functional Analysis

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Functional Analysis:

Introduction:

The *Functional Analysis* section of this report will include a black box model, functional specifications, and design metrics. The *Black Box Model* containing the input, output, and transfer characteristics will be portrayed. Each input of the *Black Box Model* will contain a list of items explaining the inputs and outputs of the system. The *Functional Specifications* will be described to answer what the system does functionally. Each main function will be broken down into sub-functions to provide a better understanding of what the design will accomplish. Lastly, the *Functional Specifications* will contain the *Design Metrics* to numerically score the design. A bulleted list of scoring criteria with definitions and units of measure will be provided.

Black Box Model:

Below Figure 2.1 shows the back box representation of the wildlife tracking system project. This is a simple way to view a complex system in terms of just the inputs and outputs and is implemented to aid in the design process by allowing the team to easily determine the overall operation of a complex system.

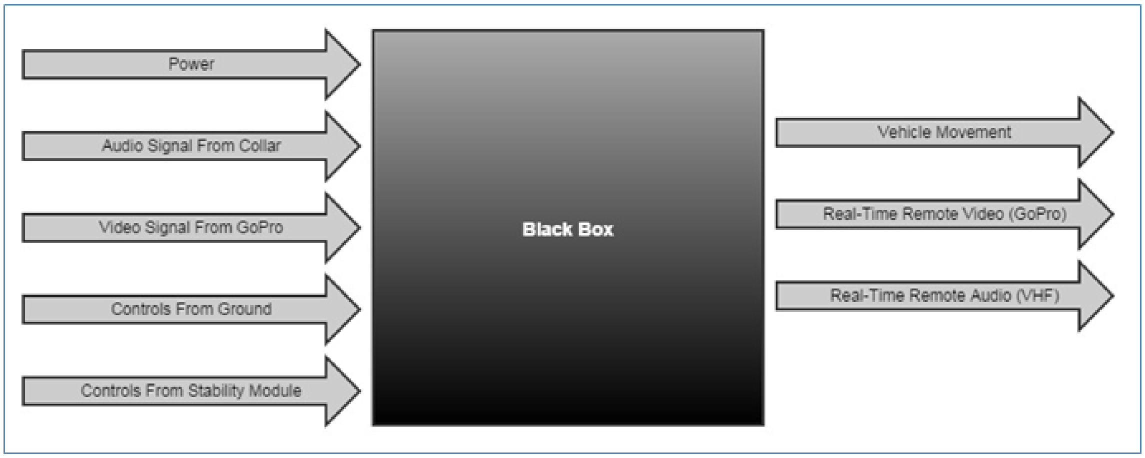

Figure 2.1: Black Box representation of wildlife tracking system

Inputs:

- Audio Signal
  - There will be an input from the VHF antennas which will be the pulse that is sent from the collar that is being tracked
- Video Signal
  - The GoPro camera that is mounted to the base of the vehicle will provide a video input signal to the system
- Vehicle controls to include flight stabilized control module (GPS included)
  - Primary control method will come from the remote control unit
  - Secondary control will come from the control module in conjunction with a GPS
- Power
  - Power for VHF antenna
  - Power for video/audio signal relay
  - Power for vehicle
  - Power for camera

Output:

- Movement
    - Thrust (up-down)
    - Pitch (forward-back)
    - Roll (left-right)
    - Yaw (rotational)
- GHz video (GoPro) relay to ground
    - Video will be relayed to ground control unit so that the pilot may see forward terrain and obstacles
- GHz audio (VHF signal) relay to ground
    - Audio will be relayed to the ground so that the pilot may zero in on the position of the collar being tracked

Functional Specifications:

The ultimate goal of this design is to find the distance and bearing to a specific collared-animal being tracked in the field. All components and subsystems of the design simply aid in this overlying goal. A quad-copter has been chosen by the MSU Ecology Department as a tool to help locate the collared-animals in the field. The user will control this quad-copter from the ground through the use of a remote control, bringing it up into flight. The user will move the quad-copter until a ping is heard, indicating that the direction of the animal has been located. Once the direction and distance to the animal have been established, the user can proceed with spotting and observing the animal as needed. The purpose of the design has been achieved, and the animal can be researched.

In order to complete the process leading up to the animal being located, several functions must first take place. Through the use of a directional antenna mounted on the quad-copter, the direction of the collared-animal can be established by rotating the quad-copter in the air (using the remote control). The directional antenna must pick up the frequency being transmitted by the collar on the animal, which is generally between 148-152 MHz. A separate transmitter (mounted on the quad-copter) will then relay a “pinging” noise back to the user on the ground when the directional antenna is oriented in the direction of the collared-animal. This “pinging” noise will be transmitted on a separate (5.8 GHz) frequency to the user on the ground. Once the user hears the noise, the quad-copter can be stopped and the exact direction of the animal can be determined through some fine-tuning of the angle of the quad-copter. The noise will get louder and more distinct as the exact orientation of the directional antenna is found with respect to the collar.

Several other sub-functions will also be in play during the flight process. In addition to the “pinging” noise, there will be a real time video feed being transmitted from the quad-copter to the user on the ground. This will also transmit over the 5.8 GHz link, and will convey video being taken from a GoPro mounted on the quad-copter. This video will aid in providing a visual for the pilot orientation for the quad-copter while in the air. The video will be displayed on a screen mounted to the remote control on the ground. Another sub-function is the flight stabilization system used by the quad-copter. This system uses a GPS function and allows the quad-copter to automatically adjust for wind and other outside forces, keeping the drone stable during flight. The final sub-function is the remote control unit itself. As mentioned earlier, this is how the user controls the quad-copter. The user will have this unit in hand while the quad-copter is in flight, allowing for complete control of all movement. All of these functions and sub-functions must be achieved without interfering with each other, which is the flaw found in other prototypes and has prevented the design from being a successfully implemented in the field.

Design Metrics:

The availability of design metrics in the early stages of design development process will allow better management and flow of later phases. More effective quality assessment of the design alternatives will be achieved by evaluating criteria in the decision matrix. The design matrices are defined in a way that will be the most meaningful to the project. This will allow for better understanding of the design constraints and easier evaluation of the quadcopter alternatives. The matrices are based on high level functional and qualitative requirements, which include: ease of use, portability, durability, safety, affordability, functionality. All of these requirements are of the utmost importance to our client. However our clients biggest concern is functionality of the tracking systems when used in conjunction with the various subsystems in at operational environment: range of the signal detection, flight time, interference and noise rejection. These constraints will be prioritized during the decision making process.

- Easy-to-use
  - Comparable to current system quadcopter setup
  - Easy to tune radio equipment and antennas
- Weight
  - Quadcopter (QC) weight w/ payload and batteries under 5 [kg]
- Altitude and range
  - Audio signal range 5-10 [km]
  - Sufficient altitude to provide range and QC to remain operational 100-1000 [m]
- Flight time
  - 30+ [min]

- Durability
  - Overall system does not impede the QC functionality and create flight problems
  - System allows for sufficient flight time
  - Operational at high temperatures >45 [C]
- Safety
  - System does not radiate harmful RF
- Cost
  - Under $5,000
- Portability
  - Complete system can fit into a car or can be assembled at the deployment location
- Signal reception
  - Audio signal is more clear than in the current system (better Signal to Interference and Noise Ratio ‘SINR’)
  - Minimum detectable VHF signal from the collar -150[dBm]
  - GPS flight control system works as in the current system
  - Video/Audio feed works as in the current system
  - Allows control of the VHF receiver from ground, which allows scanning for multiple collars remotely