Group 44 - ARC

Tech Review

Senior Capstone Project

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Abstract

Contents

1 Vision System Options - Cierra

For autonomous operation, vision systems are critical. The three main options include stereoscopic cameras, Infrared (IR) based systems such as Microsoft's Kinect, and Light Detection And Ranging (LiDAR) vision systems. With the exception of some forms of LiDar, all of these methods require what is called a disparity map, which creates a ?3D image? of the surface, that can be used for telling which objects in an image are closest or farthest away.

1.1 Stereo Vision

Stereo-vision uses two different cameras to create disparity maps in order to create a sense of depth. This is similar to how our eyes work. The biggest benefit to a stereoscopic camera system is the ability to detect objects outdoors, as the cameras are able to function with vast amounts of ultraviolet (UV) light. IR LEDs can also be used in order to illuminate an area at night, also allowing for nighttime navigation. One of the challenges of stereo vision is the computational power required. Another is clarity of the disparity map without post processing of images, which makes real-time operation more difficult. [**?**] OpenCV [**?**] contains many examples of how to configure and process stereoscopic images, and is one of the largest vision resources.

1.2 IR Camera's such as Kinect and RealSense

Using an infrared point map, these cameras are able to tell the disparity between the points, which helps in creating disparity maps. The most popular example of an IR camera system, is the Microsoft Kinect. A big advantage to IR camera?s, is the ability to function in low and non-natural lighting conditions, due to using the infrared spectrum, rather than only using the visible spectrum. The biggest problem with IR cameras, the functionality is greatly reduced outdoors, due to massive amount of infrared waves from the sun. IR cameras don?t meet our requirement of being able to use the vision system reliably outdoors.

1.3 Lidar

LiDAR works by using LAZERSSSS

1.4 Our choice

Due to the need to be able to navigate in outdoor environments, our team will start out attempting to use stereoscopic imaging as our primary vision system. We will do this using the OpenCV library to analyze the images, and create the disparity map that can be used for other purposes. If we have the computational power to post-process disparity maps in real time, we will attempt to do so.

2 Sensors - Cierra

2.1 GPS units

2.2 Encoders

2.3 Depth Sensors

3 System Control and Synchronization - Cierra

3.1 PXFmini vs Other Options

3.2 Synchronizing Sensors

4 Image Analysis Software - Dan

Image analysis, for the ARC project, is the processing of visual data received from cameras into deterministic information, such as pathfinding, or spacial awareness. This is the primary means for our autonomous vehicle to assess its surroundings and find its way to a given waypoint while avoiding obstacles. We require software that is freely available for use (via fairly liberal open source licensing), known to be correct (works well) with little modification needed, and has relatively easy to use API libraries.

4.1 DroneKit-Python

DroneKit-Python (http://python.dronekit.io/) is part of the DroneKit ecosystem (dronekit.io)

more to follow...

4.2 ArduPilot

ArduPilot (http://ardupilot.org/rover/index.html)

more to follow...

4.3 Image analysis choice

5 Telemetry Radio Communication - Dan

Telemetry is the transmition of measurement data (velocity, angle, rotation, etc.) by radio to some other place. This data is important for the human user to know the current state of the vehicle. This is especially important for autonomous operation, as the vehicle may not be operating within line of sight. Telemetry transmission is well-established, so we will not be comparing vastly different transmission technologies, such as long range (MHz radio frequencies) versus short-range (bluetooth) where the advantages of ranges of 2-15+ kilometers obviously outweigh ranges of 20-100 meters.

The main criteria for consideration are:

- Cost

  One of our main goals with ARC is to keep the costs low.
- Power consumption

  We have limited power available, therefore we need power consumption to be low.
- Ease of use

  The radio needs to be easily integrated into the autopilot system. This means it needs to have a developed API with little no modification required.
- Form factor

  The size and weight needs to be small and light. If it is too bulky, we might not have space on the vehicle. If it is too heavy, more power will be required to operate the drive system and will drain the battery faster.

5.1 3DR 915 MHz Transceiver

((https://store.3dr.com/products/915-mhz-telemetry-radio)

The 3DR 915 MHz telemetry radio has a cost of $39.99 USD for two radios. It is powered by the autopilot telemetry port (+5v) which means that has low power consumption. This radio transceiver has open source firmware, a robust API, and is fully compatible with PX4 Pro, DroneKit, and ArduPilot, using the MAVLink protocol, which will allow us to implement telemetry transmission with little to no modification of the API, should we use one of those autopilot systems. The form factor has dimensions of 25.5 x 53 x 11 mm (including case, but not antenna) at 11.5 grams (without antenna). The range of this transceiver is from 300 meters to several kilometers, depending on the antenna arrangement.

Biggest advantages: inexpensive, small form factor, low power consumption.

Biggest disavantages: range out of the box could be as low as 300 meters.

5.2 RFD900 Radio Modem

(http://ardupilot.org/copter/docs/common-rfd900.html)(http://store.jdrones.com/jD_RD900Plus_Telemetry_Bundle_p/rf900set02

The RFD900 Radio Modem has a cost of $259.99 USD for two radios. It requires seperate +5v power for operation which means that it has high power consumption. This radio has open source firmware, a robust API, and is fully compatible with PX4 Pro, DroneKit, and ArduPilot, using the MAVLink protocol, which will allow us to implement telemetry transmission with little to no modification of the API, should we use one of those autopilot systems.

The form factor has dimensions of 70 x 40 x 23mm (including case, but not antenna) at 14.5 grams (without antenna). The range of this transceiver is 25+ kilometers.

Biggest advantages: ultra long range.

Biggest disadvantages: expensive, large size.

5.3 Openpilot OPLink Mini Ground and Air Station 433 MHz

(https://hobbyking.com/en_us/openpilot-oplink-mini-ground-station-433-mhz.html) (http://www.banggood.com/Openpilot-OPLINK-Mini-Radio-Telemetry-AIR-And-Ground-For-MINI-CC3D-Revolution-p-1018904.html)

The OPLink Mini Ground Station has a cost of $26.59 USD for two radios. It requires input voltage of +5v and can be powered off the autopilot telemetry port which means that it has low power consumption. This radio has open source firmware but is only compatible with the LibrePilot RC control system. The form factor has dimensions of 38 x 23 x mm (including case, but not antenna) at 4 grams (without antenna). The range of this radio is not known, but based on the power requirements and frequency it likely has less range than the 3DR 915 MHz radio.

Biggest advantages: smallest form factor (only 4 grams), lowest cost ($26.59 USD)

Biggest disavantages: Only works with the LibrePilot control system.

5.4 Telemetry radio choice

The 3DR 915 MHz Transceiver is our selection for the telemetry radio. While the OPLink Mini Ground Station was significantly smaller, lighter, and cheaper than the other two, its implementation being tied solely to LibrePilot was a deal breaker (more information on LibrePilot can be found in the User Interface evaluation). The RF900 Radio Modem would have been a good choice, it has fantastic range and all the API options we were looking for. But it had a significantly larger form factor, required a separate power supply, and was quite expensive at $259.99. Put together, these facts eliminated the RF900 as a viable option. The 3DR 915 MHz Transceiver is a good balance of cost, performance, and size.

The cost of $39.99 for two radios, the ability to power the autopilot off the telemetry port, and the portability of its APIs and their ease of use, puts the 3DR 915 MHz at the top of our list and the clear choice for the telemetry radio going forward.

6 User Interface - Dan

6.1 QGroundControl

(http://qgroundcontrol.com/downloads/) more to follow...

6.2 DroneKit-Android

(http://android.dronekit.io/) more to follow...

6.3 LibrePilot

(https://www.librepilot.org/site/index.html) more to follow...

6.4 User interface choice

QgroundControl, for many very good reasons (no, this isn't the actual reasoning). more to follow...