High-Resolution Camera for Optimal UAV Image Acquisition

Student

Daniel Gubser

Introduction: The purpose of this semester thesis is to select and evaluate a high-resolution camera for an unmanned aerial vehicle (UAV) and how the camera can be triggered externally by an output pin of a microcontroller or a single board computer (SBC).

The requirements are as follows:

- The camera must have at least 20Megapixel.
- A spatial resolution of 1.5mm/pixel from a height of 18m must be achieved.
- The camera must be trigged by a logic level signal of at least 3.3Volt.
- The weight of the complete system must be 800g or less.
- The camera must fit on the provided Gimbal with the given dimensions [250;170;150]mm.
- The drone's speed is 4m/s, the camera must capture images at this speed.
- A microcontroller, SBC or FPGA, that has digital output pins in the voltage range of 3.3V up to 5V.
- A switch or level shifter, to make the trigger controller electrically compatible with the camera.

Approach: The thin lens equation is the basis for determining the optical system. It is used for calculating the minimal required focal length.

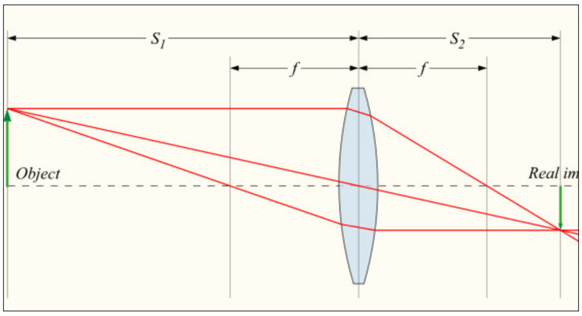
The first step for finding an appropriate camera is to gather information about the various models, which was done using a web crawler. Then this information was cleaned and used as an input for the algorithm, which calculates the minimal focal length. Afterwards the lenses for each camera could be selected. With the requirements an appropriate lens and camera was selected.

After selecting the camera the next step was to figure out how it could be triggered. The chosen camera has an external trigger input which can be used to control it. A dual N-Channel-MOSFET is used to make the 3.3V logic level of a Raspberry Pi compatible with the 1.8V of the camera.

Result: The results are summarised in the key parameters table. As can be seen all requirements except the weight are fulfilled.

With the MOSFET it is simple enough to use any control device to trigger the camera.

Thin lens equation.
https://en.wikipedia.org/wiki/File:Lens3.svg



Algorithm for calculating the minimal focal length.
Own presentment

Algorithm 1 Minimal focal length

while cameras remaining **do**
  $imager \leftarrow cameraData$
  $focalLength \leftarrow 1$
  while minSpatialResolution $>$ spatialRes **do**
    $ratio \leftarrow \frac{objectDistance - focalLength}{focalLength}$
    $fov \leftarrow imager.size \cdot ratio$
    $spatialRes \leftarrow \frac{fov}{imager.pixelCount}$
    $focalLength \leftarrow focalLength + 1$
  $camRes \leftarrow camRes.append(spatialRes)$
return $camRes$

Key parameters of the camera system.
Own presentment

Parameter	Required	Achieved
Camera dimensions [mm]	250;170;150	119.6;70.0;49.2
Imager size [mm]	-	22.3;14.9
Pixel count	>20M	32.3M (6'960;4'640)
FOV [m]	-	8.0;5.3
Spatial resolution theoretical [mm/pixel]	1.5	1.15;1.15
Spatial resolution measured [mm/pixel]	1.5	1.2;1.2
Weight [g]	800	818

Advisor
Prof. Dr. Dejan Šeatović

Subject Area
Mechatronics and Automation