USING AERIAL IMAGES TO CALIBRATE THE INERTIAL SENSORS OF A LOW-COST MULTISPECTRAL AUTONOMOUS REMOTE SENSING PLATFORM (AGGIEAIR)

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1. INTRODUCTION

Our small, low-cost, autonomous, runway free, multispectral remote sensing (RS) platform (AggieAir) has proved to be very useful for many applications [1]. The low cost and versatility of AggieAir makes RS data accessible for users with a low budget and no runway. In addition, AggieAir's quick deployment and fast data acquisition makes it a perfect platform for applications like monitoring the volume of a small lake or mapping a river at a high frequency. While the size and price of this platform makes RS data more accessible, they also present new problems with georeferencing the images. The small image footprint from the platform makes it impractical to set out ground references for each image due to the high number of images required to cover the area of interest (AOI). Furthermore, in some cases the images do not have enough features for image registration. The most practical method is to orthorectify the images using the position and orientation of the aircraft. However, this method presents issues due to the inherent errors from the inertial measurement unit (IMU) and the GPS module [2]. This paper presents a method to find the errors in the aircraft sensors using ground references and aerial imagery. This information can then be used to help calibrate the sensors and improve the precision of the orthorectification. More information on AggieAir and other platforms can be found in [1, 2, 3] and the references therein.

2. AGGIEAIR

AggieAir is an autonomous, flying wing, radio controlled (RC) aircraft (see Fig. 1a) with an onboard autopilot. The autopilot flies the aircraft according to a preprogrammed flight plan created by the user. The flight plan contains various elements like waypoints, sectors and command blocks which the aircraft uses to navigate. Feedback about the aircraft position and orientation are given to the autopilot by the GPS module and the IMU. There are a couple different camera systems which have beed developed for this platform. The latest system, which was used for the results in this paper, is called Ghost Foto (GFoto). GFoto uses an 8 MP camera (Canon Powershot SX100) and can achieve centimeter resolution while flying at a height of 200m above ground level (AGL). The camera is controlled through a USB interface by a Gumstix computer onboard the aircraft. In addition to telling the cameras when to take a picture, the Gumstix also records the data from the IMU to orthorectify the images.

3. AIRCRAFT SENSOR CALIBRATION

In some RS applications like road and river mapping, the images contain enough details to use image registration to help georeference the images. However in other applications when the AOI is a plain field, the images contain few details and orthorectification using the position and orientation of the aircraft is the best option. In both cases, precise orthorectification is important for fast data acquisition and high quality, georeferenced images. In [2], a man-in-the-loop method was used to find the errors from the aircraft sensors to improve orthorectification. This method proved to be very tedious and time consuming.

Thanks to the Utah Water Research Lab (UWRL) MLF Seed Grant (2007-2008)

The new calibration method proposed in this paper takes the man out of the loop by calculating the errors from the aircraft sensors automatically.

(a) Flying wing aircraft

(b) Aerial image with ground references

Fig. 1. AggieAir and aerial images

The aircraft sensors can be calibrated using multiple ground references in an aerial image (see Fig. 1b), and the aircraft data recorded at the time the image was taken. The position of the ground references are known and can be used to inverse orthorectify the image. This process will find the actual position and orientation of the aircraft which can then be compared to the estimated position and orientation. Knowing the actual inertial values of the aircraft will help us understand and improve the biggest contributers to the orthorectification error: GPS bias (including altitude), GPS computational delay, and yaw. The GPS bias can be corrected statically with a known position on the ground. However this bias, along with the bias in the yaw, may vary with time and location. This method can provide a solution to this problem by calibrating these properties before each flight. Unlike the GPS bias, the GPS computational delay may only be seen while the aircraft is in motion. Therefore, this method should also provide a good technique to characterize this property.

4. CONCLUSION

Using many images taken of the same set of ground references but at different altitudes, speeds and headings, the inertial sensors of the aircraft can be characterized, and the errors found can be used to improve the precision of the orthorectification and the quality of the data. Future work includes automating the process further using target recognition.

5. REFERENCES

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