Journal of
Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7766186

AERIAL IMAGERY BASED ON CAMERA AXIS IN VERTICAL POSITION USED IN MAPPING

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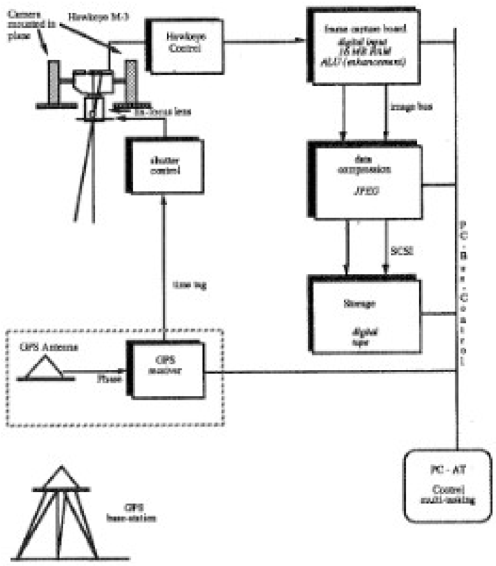
Abstract- This paper explores the use of an advanced airborne imaging system equipped with GPS for vertical image acquisition. The system utilizes a high-resolution camera mounted on an aircraft to capture vertical images, which are tagged with GPS time and the precise position of the aircraft. The collected images are processed along with the route data and stored in an image database linked to a GIS. The study focuses on the accuracy of the system, taking into account various factors such as GPS positioning, camera parameters, and aerial triangulation. Kinematics GPS is used to determine the position of the aircraft and image stations within 10centimeterss. Aerial triangulation is used to adjust for additional camera parameters using GPS data for perspective canters. The primary application of this system is expected to be in mapping utility lines, roads, and pipelines. Additionally, the system can be used for generating digital elevation models and orthophotos for planning applications.
The results of the study will provide insights into the effectiveness and potential applications of the advanced airborne imaging system. This thesis will be beneficial for researchers and professionals in the field of remote sensing, geospatial analysis, and mapping.
Key words*- Aerotriangulation, Camera, Digital Systems, GPS, Integrated System, CNN,* Aerial Images, Clump Normalization

INTRODUCTION

The Ohio State College's Centre for Mapping may dedicate a considerable portion of its research endeavours towards developing more flexible and versatile mapping frameworks. Among these frameworks, the GPS-Van has received considerable attention. This system, which is vehicle-based, combines GPS, inertial sensors, and an advanced stereo-vision framework to create a thruway inventory (Novak, 1991; Bossler et al., 1991). The same sensors utilized within the GPS-Van can also be integrated into an aircraft. While some components found in the aircraft, such as the inertial system or a small camera, are non-essential, interpretive triangulation techniques can accurately reconstruct the parameters measured by these devices. In this paper, we present MapCam, a computerized aerial mapping system. MapCam includes a state-of-the-art, high-definition, diagram CCD camera that captures imagery at pre-defined intervals and stores the data on an advanced tape. The GPS collector, operating in kinematic mode, accurately tags the photographs with the aircraft's location during post-processing, thereby regulating airborne triangulation. All data collected during the flight is uploaded to a geographic information system (GIS) with flight-lines and introduction stations serving as a geographical reference, allowing for the images to be uploaded and stored relative to these locations as quality. With an extensive layout menu, any picture can be easily accessed on the computer screen by selecting the specific geographical region in which it was captured. The system's name, MapCam, reflects its capabilities in providing comprehensive and accurate aerial mapping data. Using a post-processing workstation, you can perform all photogrammetric procedures, such as picture arrange estimate, ethereal triangulation, DEM, and highlight extraction, semi-automatically. The deleted information is easily accessible within the geographic information system. Airborne triangulation that is controlled by GPS is currently undergoing operational connection by a variety of organisations (Lapine, 1990). In any event, according to our information, all applications relate to metric, ethereal, film cameras, which means that the examination of the symbolism must be done by a chairman on an analogue or expository stereo-plotter. The primary function of GPS is to apportion with ground control in order to perform ethereal mapping. Electronic cameras have been used in aeroplanes for the goal of identifying and preventing blocked off areas. Analog video cameras were used in the majority of the moo assurance investigations. For the purpose of utilising computers in airborne mapping, some revolutionary sensors, such as the Mothers camera (Ebner et al., 1991), have been developed. Both are based on a pushbroom sort of CCD cluster, which enables in-flight stereo by a vertical, in addition to a forward-looking channel and an aft-looking channel. The tall fetched nature of these systems, which are for the most part at the model organise, as well as the complicated geometrical camera display have shown that their wide movement to this point has been disallowed. To our data no one tried with high-resolution outline CCD cameras beside GPS in airplanes. Several distinct perspectives on the development of MapCam are investigated within the scope of this research. The various parts of the apparatus are going to be described in the chapter that comes following this one. At that time, we clarified the scientific appearance, to which we had joined in order to carry out airborne triangulation and camera calibration. Many things, including digital elevation models (DEMs) and computer-generated orthophotos, are computed and presented in a three-dimensional point of view. The flexibility of MapCam is demonstrated throughout the book's last chapter by presenting many potential applications.

HARDWARE COMPONENTS

A computerised, high-assurance CCD camera, a GPS collector, and a computer-control and capacity unit are the three primary elements that make up the MapCam system. It's possible that our CCD camera is a Kodak Hawkeye M-3 (figure 1), which incorporates a CCD sensor with a resolution of 1280 (H) x 1024 (V) pixels inside the body of a regular Nikon F-3 camera. The Nikon camera's gizmos serve as the mechanisms for the presentation's control mechanisms. It employs a central plane shade in the form of a slit. The CCD sensor sends digital information to a diagram buffer, which is located in a detached box adjacent to a flexible hard drive that can store a maximum of 120 images. The Hawkeye M-3 camera has the ability to run off of a battery and is compact enough to be taken around effortlessly. Via the use of a SCSI interface, we were able to connect the data-capture box to a more advanced tape drive (Exabyte) in an effort to circumvent the challenges that were presented by the hard disc. In addition, we incorporated a data-compression board with the purpose of lowering trade prices and freeing up capacity space. It is possible to store up to 5 gigabytes worth of uncompressed data on a single exabyte tape, which is equivalent to 3,850 photographs. At the moment, the rate of data transfer is limited to one photo every single second. We experimented with two distinct kinds of GPS systems: for metric mapping applications, we utilised a coordinate of Trimble 4000 ST survey-quality beneficiaries. They operate in a kinematic mode, which suggests that one of them be installed on the fuselage of our top-wing plane and the other should be situated over a recognised base-station. They are both keeping track of the stages that the GPS carrier hail is going through and providing a clock that can be used to synchronise all of the MapCam components. Because the presentation stations may be selected to an accuracy of greater than 10 centimetres, we will be able to fully eliminate ground control for aero-triangulation if we use these kinds of beneficiaries. In any event, once the GPS radio wire of the aeroplane has been started over a recognised target on the runway, the follower bolt needs to be maintained with the utmost diligence. In light of this, it appears that the pilot will need to do exceptionally wide spins while maintaining control of the aircraft. We presented a system based on Navstar real-time differential GPS for the objectives of roughly organising the plane and determining the path. This equipment communicates the base-station corrections to the airplane's beneficiary through a radio interface in order to facilitate the establishment of a more advanced position as quickly as possible. The accuracy of this method is within an amplitude of 1 to 5 metres as pseudo-ranges are measured, which is adequate for a variety of more distant detecting tasks as well as tagging the photographs in a database. At long last, the system is being directed by a board-level personal computer, which, together with the majority of the system's other components, is housed in a flexible box. We do not use a hard disc within the plane because the capacity requirements while it is operating are modest; instead, a small RAM disc was incorporated in the aircraft. The programme on the personal computer receives time signals from the GPS beneficiary; using those signals, it computes the contrasting introduction time of the camera and then activates the screen. The user interface for customers is a flat screen with a touch board superimposed on top of it. It seems that information from all of the sensors, along with a short video picture showing the extent secured by the initial subsequent introduction, has been displayed. It appears information from all sensors, as well as a small video picture of the extend secured by the.



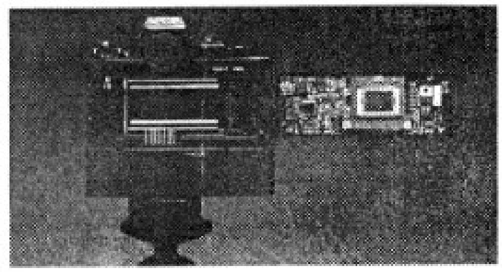


Figure 1: The Hawkeye M-3 high-resolution, digital camera system

Figure 2: Layout of the complete MapCam system

Because there is no comfort, the customer picks capacity by just touching the appropriate buttons on the touch screen. Figure 2 displays a chart that is representative of the entire MapCam system. Take notice that the GPS units are interchangeable depending on the requirements of the application for the level of precision it requires. This equipment was handed over to the Ohio Office of Typical Resources via a Cessna 207 plane that they owned.

SYSTEM CALIBRATION

In order to utilize MapCam for airborne mapping purposes, it is necessary to calibrate all sensors, including the Hawkeye M-3 and GPS. This calibration involves selecting the appropriate camera geometry and accounting for any distortions, as well as determining the GPS antenna's arranged center in relation to the viewpoint center of the advanced camera. Additionally, it is essential to factor in any time delay between the camera's coverage and its actual introduction in order to ensure accurate and precise results.

(i) Camera Geometry- When it comes to camera geometry, the Hawkeye M-3, which relies on major components of an amateur camera (Nikon F-3), presents certain uncertainties in terms of its introduction. However, we can assume that the CCD sensor itself is free of twists, such as unflatness or irregularity of pixel-dividing, as indicated by the manufacturer of the sensor (Kodak), which specifies the degree of its square pixels as 16 microns. This translates to a sensor degree of 20.48 mm x 16.38 mm, which is smaller than the conventional 35 mm film. As a result, we must use a considerably shorter central length to initiate wide-angle coverage. To this end, we have selected a 20 mm focal length, which has been properly focused to infinity. To ensure that the internal alignment of the camera remains unchanged during the mapping process, we taped the centering ring at its designated position. Before proceeding with the airborne mapping using the camera, we conducted a precalibration using a 3-dimensional test-field that we set up on a building located at The Ohio State University. The precalibration process aimed to accomplish a number of goals, including establishing the ideal values for the central point and the central length, as well as determining the degree to which the central point was distorted. Standard descriptive approaches, in particular the bundle-solution with self-calibration and additional parameters, were applied so that we could achieve these goals. The consequences of this adjustment highlighted the enormous potential that an improved camera with a high resolution had. The arrangement of the bundle also took into account any distortions, which, when rectified appropriately, might greatly improve the findings (refer to Table 1). These criteria will be used for airborne triangulation to decide whether or not every group of photos requires their own individual self-calibration.

(ii) Radio wire Counterbalanced- The vector between the perspective center and the stage-center of the GPS radio wire must be gathered. This adjusted can be included inside the aerotriangulation as control data. The counteracted vector must be chosen inside the picture facilitate framework (figure 3). It is associated to bundle change by imperative (2) which relates a perspective center Oi with the comparing GPS position Gi. The counteracted vector ΔO is changed into the ground encourage system by the turn grid Ri.

$$G_i = O_i + \underline{R}_i\,(\underline{\Delta R}_i)\,\underline{\Delta O}$$

with: G_i........*GPS position for exposure station i,*
O_i........*perspective center of image i,*
$\underline{R}_i$........*rotation matrix of image i,*
$\underline{\Delta R}_i$......*correction for camera leveling if recorded during the flight,*
$\underline{\Delta O}$.......*offset vector in the image coordinate system.*

The adjusted vector is tied to the development of the plane. On the off chance that the camera is joined to a mount which can be leveled amid the flight, which suggests that the heading of the vector changes relative to the picture organize system, it must be duplicated by another turn system ΔRi that considers these state of mind changes. ΔRi can because it were be computed, within the occasion that the precise changes caused by leveling the camera mount are naturally recorded in the midst of the flight. In our tests we did not change the camera mount in the midst of operations, so that the starting calibration was kept up and ΔRi may be excluded.

Method	x_p [mm]	y_p [mm]	c [mm]
interior orientation	-0.009 (±0.011)	-0.409 (±0.011)	20.281 (±0.019)
w/radial	-0.141 (±0.004)	-0.434 (±0.004)	20.354 (±0.006)
w/radial and decentering	-0.152 (±0.008)	-0.337 (±0.009)	20.371 (±0.006)

Table 1: Results of the pre-calibration of the Hawkeye camera

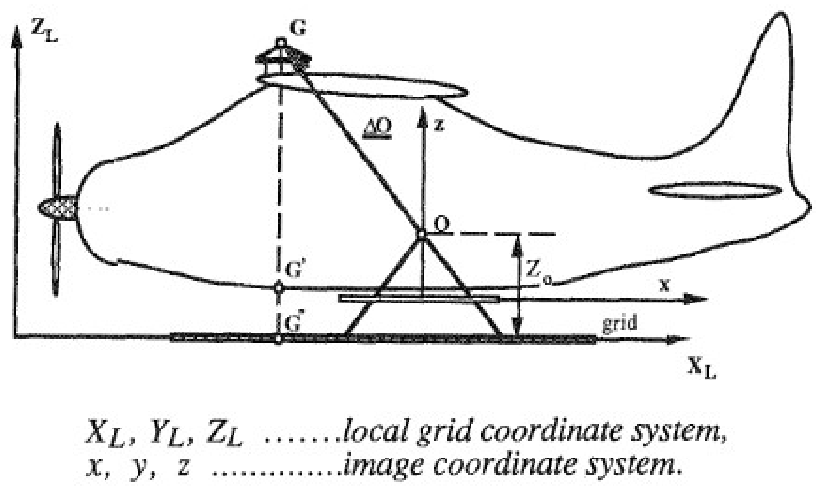


Figure 3: Calibration of the offset vector in the image coordinate system

(iii) Time Delay of the Shade- Amid our to start with test flights we found that there's a delay between the introduction time recorded by the computer and the time when the-shutters really opened. This can be regularly due to the reality, that the PC sends a hail to the Hawkeye and records the GPS time of this hail. In any case, the introduction is to some degree conceded due to the equipment transmitting the flag. This delay can be as sweeping as 1 millisecond, which compares to an counteracted of 5 cm in case the discuss transport is traveling at a speed of 160 km/h. There are two ways to calibrate this delay Δt: to start with, one can endeavor to degree it with an oscilloscope and a light delicate diode behind the shade. This would tell us, how long the camera takes to answer, once the hail was transmitted from the PC. The other approach would endeavor to redress for Δt by an additional block-invariant parameter within the bundle arrangement.

OPERATION OF MAPCAM AND POST-PROCESSING

During the trial runs of the primary configuration of the MapCam system, we made use of a Cessna 207 aircraft. Since the aircraft had a gap and camera mount inside the foot, we had to introduce a small connector to accommodate our Hawkeye camera. The installation of all the necessary equipment took approximately thirty minutes, excluding the calibration process which was done separately. Subsequently, a basic operational test was conducted in the hangar before the aircraft was flown to a predetermined target located on the runway of the airport. We utilised a Cessna 207 aircraft for the test flights of the principal configuration of the MapCam system. These flights served as evaluations. We were forced to install a minor connector in order to accommodate our Hawkeye camera because the aircraft already had a gap and a camera mount within the foot. The procedure of installing all of the essential equipment took about thirty minutes, although that time did not include the calibration step, which was performed in a different setting. After that, a fundamental test of the aircraft's functionality was carried out in the hangar, and then it was flown to a designated target that was situated on the runway at the airport. We were able to conduct both of our test flights without experiencing any cycle-slips, which is a potentially problematic occurrence that may have led to inaccurate data collecting. After the conclusion of each test flight, which lasted for longer than an hour, the crew went back to the previously identified target on the runway in order to finish the survey. To begin recording photographs with the MapCam while the aircraft is in flight, the operator needs to do nothing more than click a single button. The photos can be taken at intervals of more than one minute or at an interval that has either been predetermined or is defined by the user. Because of its intuitive design and rock-solid dependability, the MapCam system is an exceptionally helpful instrument for aerial mapping and information gathering. In the scenario that was just described, MapCam uses real-time data from GPS to determine the speed of the aeroplane and how its position is shifting in relation to other objects. Following the completion of the flight, the post-processing of the GPS estimations is finished by integrating the recognitions of the base stations and the meanderer stations. Analyzing either pseudo-ranges or stage estimations is possible, depending on the requirements that have been set. As a result we get the flight-lines with the pictures joined as properties (figure 4).

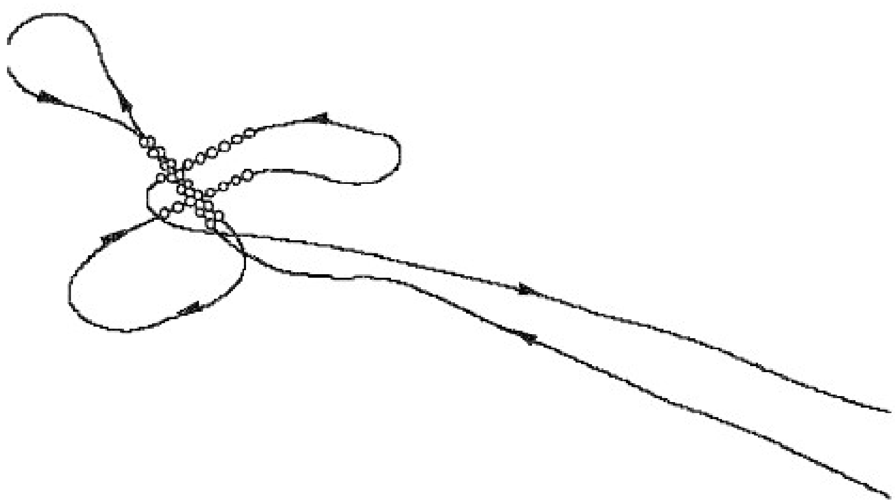


Figure 4: Flight-lines of the first testjlight after differential GPS processing

The ERDAS Advanced Ortho Module is a digital image processing system that permits image organisation and measurement on a computer screen. This module was used to undertake the analysis of the photographs that were obtained from MapCam. During the course of this research, numerous check and tie-points were measured within the digital images in order to calculate a bundle triangulation with the GPS flight-lines, internal orientation, and adjusted vector. This was done in order to assist with determining the exterior presentations of all photographs. This important introductory data can be put to use for a variety of post-processing activities, such as the creation of digital elevation models (DEMs) and orthophotos. Figure 5 is an example of one of the MapCam photographs that was taken, and it features the Columbus Zoo

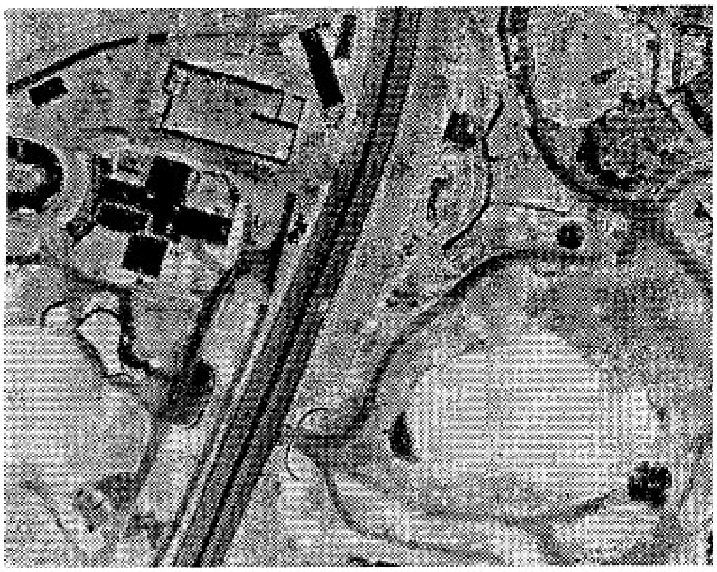


Figure 5: MapCam image covering the Columbus Zoo

CONCLUSION

The development and application of advanced airborne mapping systems have greatly improved the accuracy and efficiency of mapping for various applications. The MapCam system described in this paper is a prime example of such systems that combine high-definition cameras, GPS, and GIS to capture and store aerial images with precise location data. The calibration process of the camera and sensors, including precalibration and self-calibration, is crucial for achieving accurate results. The potential of high-resolution cameras in combination with the bundle solution and self-calibration has been demonstrated, offering improved outcomes. The flexibility and versatility of these mapping systems have made them invaluable tools for mapping utility lines, pipelines, roadways, and creating height models and orthophotos for planning applications. Overall, the advancement and application of these mapping systems have greatly improved the accuracy and efficiency of mapping, benefiting various industries and applications.

The development and use of advanced mapping technologies such as MapCam and GPS-Van have revolutionized the field of airborne mapping. These technologies have allowed for more precise and efficient mapping of large areas, making it possible to collect high-quality data for various applications such as land use planning, environmental monitoring, and infrastructure development.

Through the research conducted on camera geometry, calibration, and distortion, it has been determined that precalibration using standard descriptive methods such as the bundle-solution with self-calibration and additional parameters is crucial for achieving optimal results in airborne triangulation. The use of advanced sensors such as the Hawkeye M-3 and GPS in conjunction with these mapping technologies has further improved the accuracy and efficiency of airborne mapping.

Moving forward, continued research and development of mapping technologies will be essential for meeting the growing demand for accurate and up-to-date mapping data. This will require collaboration between researchers, industry professionals, and policymakers to ensure that mapping technologies are used effectively and responsibly for the benefit of society.

Overall, the advancements made in airborne mapping technologies have had a significant impact on various industries and have the potential to continue driving progress in areas such as urban planning, agriculture, and natural resource management. With further research and development, these technologies can help address some of the world's most pressing challenges and contribute to a more sustainable future.

This would make it possible to carry out stereo placement within the context of a neighbourhood organising framework in relation to the plane. In the event that the plane was able to fly for the most part normally, the precision would be satisfactory for a number of different purposes. In order to encourage overall organisations, three GPS receiving wires would be presented at the wingtips and the vertical stabiliser. This would be done in a three-wire configuration. These would provide both positions throughout the planet and states of intelligence for the flying machine. We realise that this so-called Utility Mapping System, which is currently being sketched out at the Ohio State College, will enable the client to layout around the world and of an aircraft in real-time.

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