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*Research Article*

# Camera calibration parameters: An Estimation for navigation of Micro Aerial Vehicle

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Vision-based algorithm based on camera standardization technique is proposed in this paper to figure out the Internal and External Camera Requirements. The CMOS Polaroid sensor module is integrated into the Micro Aerial Vehicle to capture framed image frames with a resolution of 480x640 pixels. Internal parameters, namely Focal length, main point, Skew and Distortion coefficients are calculated in the order of the image frames with the pattern. The main purpose is to measure the camera in real-time navigation of a small aerial vehicle and to determine the reference angle of the reference axis. Using the camera measuring method, the camera's internal parameters are computer-generated. If the internal parameters are known, the external camera parameters are measured in consecutive image frames obtained using the CMOS camera sensor module. Planar pattern is used for real-time camera measurement. By using a rotating vector and translator of the camera, rotational movement and translation of a small aerial vehicle can be measured. The title effects obtained by camera measurement were verified using the Arduino based MPU6050 sensor module.

*Keywords:* Camera Adjustments, Small Air Vehicle, Map-Reading , Planar method.

## 1. Introduction

Small Aerial Vehicles (MAVs) have become much popular in different programs. Because of their size and weight, small aerial vehicles are locally available also vary geographically. Equipped with additional sensors, MAVs can make independent flights. The independence of the Unmanned Aerial Vehicle with total order weight less than or equal to 1kg, though it is hard to bound the valuation only to self-regulation as the development of the stadium represents a challenge in itself. Even though the range of commercial products is from 5 to 350 g are available, most of these products never bring the sensors and processors which is vital for automatic air transport.

Several small airlines do not have the persistence required for a voyage of more than 5 minutes. Long-term persistence involves large batteries, and the current capacity of Li-polymer batteries (for the order of several hundred Wh / kg), a large fraction used by key batteries, usually between 25-50% of the enormous weight.

There are many types of micro-UAVs which are different stages of research, development, and implementation. MAVs can automatically find pedestrian or low-cost vehicles with hard-to-reach access. This could be for example disaster areas, where the MAV provides rescue teams with specific purpose information. In order to make these machines, the most accurate navigation solution is always needed. Typically, MAVs are equipped with Global Navigation Satellite System (GNSS) receivers, which provide complete space and assist Inertial Navigation System

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(INS). However, this type of navigation system is not enough because MAV should also be able to operate in GNSS restricted areas, such as indoor conditions. In addition, urban canals, multi-channel distribution and tagging are the reasons for GNSS's low level of accuracy. Therefore, certain equipment such as a camera is required. The Polaroid quickly discovers features, which are tracked to make the visible movement. Reflection processing of the MAV system image camera rotation dynamic environment.

### *1.1. Need for camera adjustment*

Camera adjustment is the technique of valuating amplitude of the camera adopting portrait of a special positioning template. Parameters include internal camera, distortion coefficients and external camera. Using these camera frames to remove lens distortion effects on the image, to adjust the layout, to recreate 3-D scenes on multiple cameras, and to make other computer vision applications to create a mathematical model for that camera. Camera calibration is done by combining information about the location of the visual camera with the measurements found in the image.

## 2. Proposed methodology

This paper proposes a vision-based navigation algorithm to measure internal and extrinsic camera parameters. A diagram of the proposed block path is shown in Figure 1. The camera matrix is calculated by the proposed camera algorithm using external and internal data. External criteria designate a robust transition from a 3-D connection system to a 3-D camera connection system. Internal criteria designate a visual transition from 3-D camera consoles to 2-D image links. Camera calibration is done using a chessboard pattern.

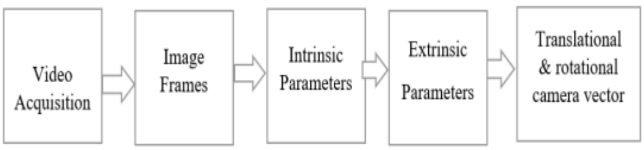


**Figure 1. Block diagram of the proposed methodology**

Figure 2. Shows the extraction of the camera calibration parameters. Camera coordinate scan be extracted from the world coordinates. Camera coordinates can be obtained from the world coordinates using rigid 3D to 3D transformations. Using the projective 3D to2D transformations, pixel coordinates can be obtained from the camera coordinates.

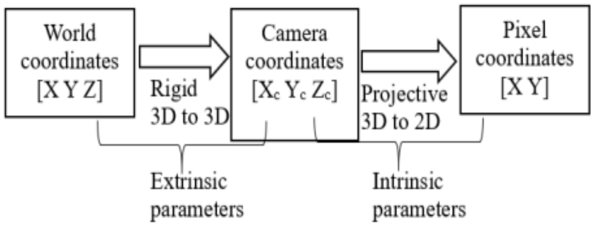


**Figure 2. Camera Calibration Parameters**

The 3-D camera links converted into 2-D image links are visual changes that represent the camera's internal parameters. External camera parameter designate a solid transition from 3-D world to 3-D camera integration. Internal camera parameters include focus length, main point, and skew coefficient. The internal camera matrix, K, is calculated as follows.

$$K=\begin{bmatrix} f_x & 0 & 0 \\ s & f_y & 0 \\ c_x & c_y & 1 \end{bmatrix} \quad (1)$$

## 3. Hardware for real time implementation

The computer hardware used for the implementation of the vision-based camera algorithm is described in the next paragraph.

### *3.1. Arduino Uno*

Arduino Uno features a USB interface, 14 virtual I / O pins, 6 analog connectors, and a small Atmega328 controller. It additionally helps serial transmission the usage of Tx and Rx pins. there are numerous versions of Arduino forums introduced available on the market inclusive of Arduino Uno, Arduino Due, Arduino Leonardo and Arduino Mega. it's far an open source platform for boards and software program which are conveniently available to transform and enhance forums for higher performance. The software used for Arduino gadgets is known as IDE (incorporated improvement region). it may be edited the use of C and C ++ languages. figure three suggests the Arduino board.


**Figure 3. Arduino board**

*3.2. MPU6050 Sensor*

The specifications of the MPU6050 Sensor is given below

• MEMS 3-aixs accelerometer with integrated values of 3-axis gyroscope
• Energy deliver : 3-5V
• Communication: I2C Convention
• 16 built-in ADC provides high exactness
• Built-in DMP provides maximum integration capacity
• Can be utilized to communicate with other IIC devices such as a magnetometer
• Adjustable IIC address
• Gyroscopes array: +/- 250 500 1000 2000 degree / sec
• Speed array : +/- 2g, +/- 4g, +/- 8g, +/- 16g
• Built-in temperature sensor

MPU6050 Sensor is shown in Figure 4.

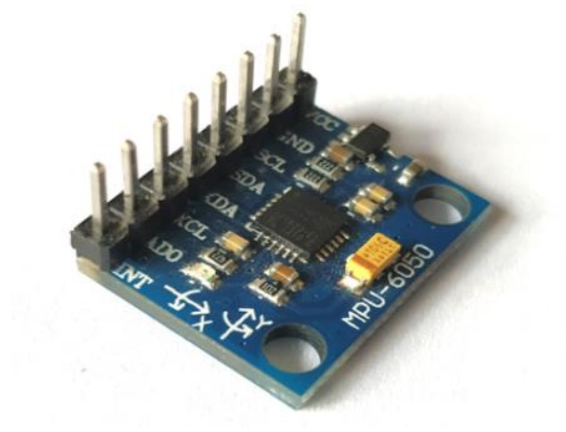


**Figure 4. MPU6050 Sensor**

*3.3. Camera Sensor*

The Etrontek SSP268 is an integrated USB 2.0 High-Speed (HS) and Full-Speed (FS) camera. It has 3 built-in LDOs to enable the CIS module and USB control. Camera sensor features are provided below

• CMOS Sensor Module Interface
• Login: 8-bit YUV422
•Repairing : VGA (640x480) and 1.3M (1280x1024)
• Support JPEG encoded streaming in transit mode
• USB 2.0 high speed and full speed
• UVC 1.1 is compatible
• Support Isochronous end point (video, 24MB / s max.)
• Supports remote control awakening from USB event
• Embedded 8051 with 32KB mask ROM and 2KB SRAM
• Up to 48MHz
• UART debugging
• Up to 8 GPIOs (6 GPIOs for 40-QFN)

**Figure 5. Camera Sensor**

Arduino board is interfaced with the MPU6050 sensor as shown in Figure 6. The Camera module is affixed on this setup to get the motion related parameters like acceleration and rotational velocity of the camera as shown in Figure 6.

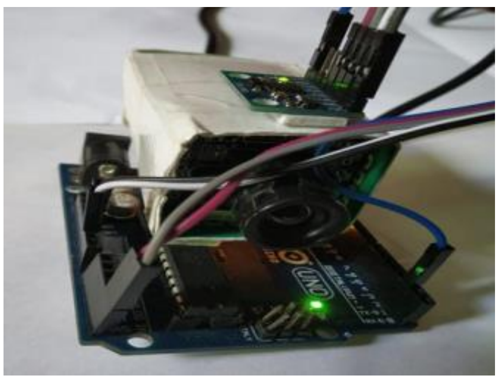

**Figure 6. Camera and Arduino Setup**

## 4. Experimental results and discussions

Camera scaling method is used to calculate the camera location at the scene. Planar pattern photo frames are obtained using Etrontek SP268 with image resolution of 640x480 pixels. Links between 3D earth points and 2D image points are obtained using multiple image frame frames. In this work, the chessboard planar pattern is used as a measuring pattern to measure the internal and external parameters of the camera. 3D world points can be converted into camera links using external computer parameters. Mapping directs the camera to a photo plane using the camera's internal parameters. Scale image frames obtained with different angles and views are shown in Figure 7.

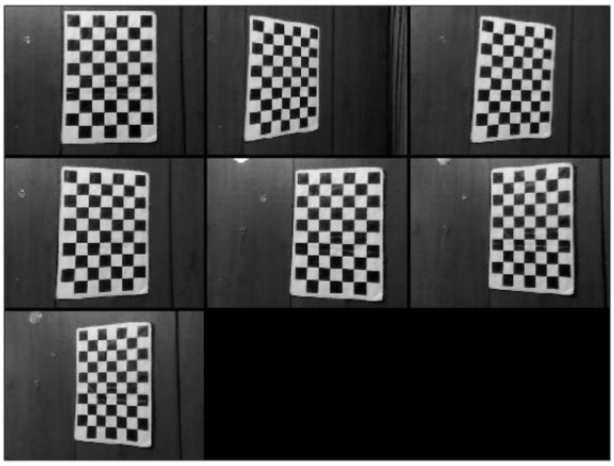

**Figure 7. Camera calibration input image frames**

Calibration pattern is detected in the image frames. Grid corner points were extracted from the planar pattern. Corner coordinates for the squares on a checkerboard was extracted as shown in Figure 8. The number of squares in both the x and y directions of the pattern is 10 × 7 respectively.

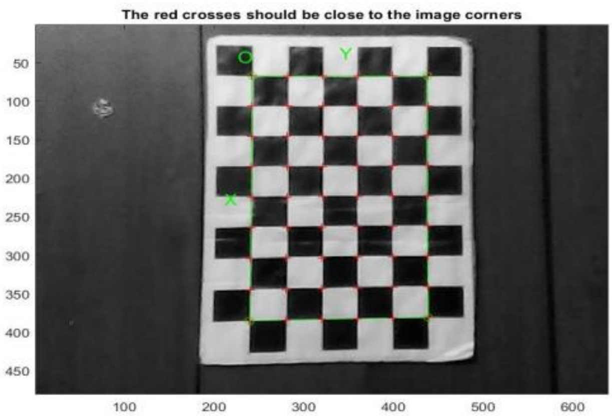


**Figure 8. Grid corners extracted in planar pattern**

Grid corner feature points were extracted from the planar pattern image frames acquire data different angles such as 30, 20 & 10 degrees respectively. The Planar camera calibration pattern image frame acquired at an angle of 30 degree is shown in Figure 9.

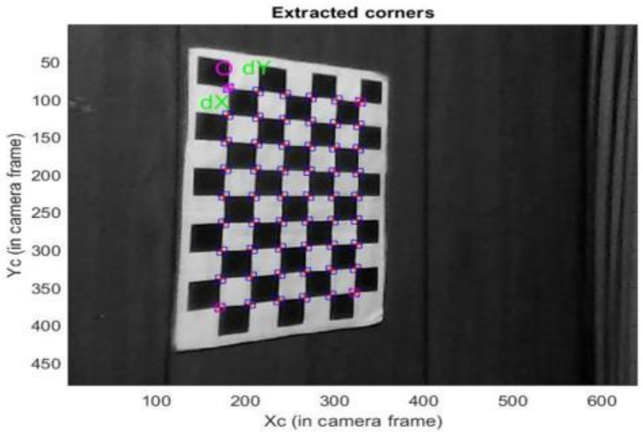


**Figure 9. Planar pattern image frame captured at an angle of 30 degree**

3D earth points are applied and the image points are drawn to the frame pattern frames, the inner and outer boundaries of the camera are computerized. Internal camera parameters are computer-generated after launch and development and the values obtained are shown below.

Evaluation parameters after implementation:

Duration: = [690.52829 690.52829]
Primary Poi = [319.50000 239.50000]
Skew: = [0.00000] => pixel angle
= 90.00000 degrees
Distortion: = [0.000 0.000 0.000 0.000 0.000]

Post-full (uncertain) measurement results:
Place Length: = [878.83443 875.44198] +/- [21.23877 19.91406]
Key point: = [436.61649 207.80810] +/- [11.36289 9.18731]
Skew: = [0.00000] +/- [0.00000] => pixel axis angle = 90.00000 +/- 0.00000degrees
Distortion: = [0.08129 0.93379 0.01825 0.02430.00000] +/- [0.06077 0.48028 0.00525 0.00759 0.00000]
Pixel error: = [0.33791 0.25943]

The computed extrinsic camera parameters are shown in Figure 10. The Extrinsic parameters is computed from the previously computed Intrinsic parameters. The extrinsic parameters are obtained as 3D grid location in camera reference frame. The extrinsic parameters are coded in the form of a rotating matrix and a translation vector.

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Extrinsic parameters:

Translation vector: Tc_ext = [ -159.636018   -63.351486      877.106681 ]
Rotation vector:   omc_ext = [ 1.943764      1.831151    0.554433 ]
Rotation matrix:    Rc_ext = [ 0.057433      0.834702    0.547699
                               0.998323     -0.052030   -0.025393
                               0.007301      0.548239   -0.836290 ]
Pixel error:           err = [ 0.26244   0.19831 ]

fx >>
```

**Figure 10. Computed extrinsic camera calibration parameters**

The position of a small aerial vehicle, i.e., a rotating vector, the rotating motor of a vehicle can be calculated on the translating and rotating vector of the camera obtained from the proposed camera measurement.

## 5. Conclusion

Vision-based algorithm based on camera calibration method was proposed measurement.

Using internal and external camera parameters, Planar pattern images were captured.

Using the CMOS camera sensor module mounted on the Micro Aerial Vehicle, corners were extracted in the sequence of image frames with an accuracy 0.1 pixel. Calculated external camera parameter values are used to compute the Rotational and Translational vector of the camera about the yaw axis.

This rotational and translational camera vector values can be used to estimate the heading and for the navigation of the Small Air Vehicle.

## REFERENCE

[1] Zhang, Z. “A Flexible New Technique for Camera Calibration.” IEEE Transactions on Pattern Analysis and Machine Intelligence. Vol. 22, No. 11, 2000, pp. 1330–1334.

[2] Heikkila, J., and O. Silven. “A Four-step Camera Calibration Procedure with Implicit Image Correction.” IEEE International Conference on Computer Vision and Pattern Recognition,1997.

[3] Azra Fetić, Davor Jurić i and Dinko Osmanković. “The procedure of a camera calibration using Camera Calibration Toolbox for MATLAB” IEEE International Conference, 2012.

[4] Roger Y. Tsai. A Versatile Camera Calibration Technique for High-Accuracy 3D Machine Vision Metrology Using Off-the-shelf TV Cameras and Lenses. IEEE, Journal of Robotics and Automation, Vol. RA-3, August 1987.

[5] Janne Heikkilä, Olli Silvén, A Four-step Camera Calibration Procedure with Implicit Image Correction, Computer Vision and Pattern Recognition, 1997.

[6] Faugeras, O. D. & Toscani, G. (1987) Camera calibration for 3D computer vision. Proc. International Workshop on Industrial Applications of Machine Vision and Machine Intelligence, Silken, Japan, p. 240-247.

[7] Janne Heikkilä, Olli Silvén, (1996) Calibration procedure for short focal length off-the-shelf CCD cameras. Proc. 13th International Conference on Pattern Recognition. Vienna, Austria, p. 166-170.

[8] Melen, T. (1994) Geometrical modelling and calibration of video cameras for underwater navigation. Dr. ing thesis, Norges tekniske høgskole, Institutt for teknisk kybernetikk.

[9] Shih, S. W., Hung, Y. P. & Lin, W. S. (1993) Accurate linear technique for camera calibration considering lens distortion by solving an eigenvalue problem. Optical Engineering 32(1): 138-149.

[10] Slama, C. C. (ed.) (1980) Manual of Photogrammetry, 4th ed., American Society of Photogrammetry, Falls Church, Virginia.

[11] Tsai, R. Y. (1987) A versatile camera calibration technique for high-accuracy 3D machine vision metrology using offthe-shelf TV cameras and lenses. IEEE Journal of Robotics and Automation RA-3(4): 323-344.

[12] Wei, G. Q. & Ma, S. D. (1993) A complete two-plane camera calibration method and experimental comparisons. Proc. 4th International Conference on Computer Vision, Berlin, Germany, p. 439-446.

[13] Weng, J., Cohen, P. & Herniou, M. (1992) Camera calibration with distortion models and accuracy

evaluation. IEEE Transactions on Pattern Analysis and Machine Intelligence PAMI-14(10): 965-980.

[14] Abdel-Aziz, Y. I. & Karara, H. M. (1971) Direct linear transformation into object space coordinates in close-range photogrammetry. Proc. Symposium on Close-Range Photogrammetry, Urbana, Illinois, p. 1-18.

[15] Faig, W. (1975) Calibration of close-range photogrammetric systems: Mathematical formulation. Photogrammetric Engineering and Remote Sensing 41(12): 1479-1486.