

DIGITAL IMAGE STABILIZATION FOR VIBRATION REDUCTION  
OF VIDEOS CAPTURED FROM UNMANNED AERIAL VEHICLE  
(UAV)

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## **ABSTRACT**

The purpose of this project is to study and investigate possible methods to reduce the vibration of videos captured using the unmanned aerial vehicles (UAV) using digital stabilization. The digital stabilization is divided into three modules, image registration or motion acquisition, motion vector estimation and motion vector compensation. In this project we propose to obtain the image registration using an enhance Block Matching Algorithm, and using a local temporal Gaussian filter as the vector compensation. This matching gives us a good result in terms of the computational speed and the image stabilization.

## **ABSTRAK**

Tujuan projek ini adalah untuk mengkaji dan menyiasat kaedah yang mungkin untuk mengurangkan getaran video yang ditangkap menggunakan kenderaan udara tanpa pemandu (UAV) yang menggunakan penstabilan digital. Penstabilan digital dibahagikan kepada tiga modul, pendaftaran imej atau pemerolehan gerakan, gerakan vektor anggaran dan vektor pampasan gerakan. Dalam projek ini, kami mencadangkan mendapatkan pendaftaran imej menggunakan Algoritma Blok Padanan, dan menggunakan penapis Gaussian tempatan sebagai pampasan vektor. Pemanduan ini memberikan kita hasil yang baik dari segi kelajuan pengiraan dan penstabilan imej.

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## LIST OF ABBREVIATIONS

BMA	-	Block Matching algorithm
BPM	-	Bit Plane Matching
DIS	-	Digital Image Stabilization
FPS	-	Frame per Second
GMV	-	Global Motion Vector
MAD	-	Mean Absolute Difference
ME	-	Motion Estimation
PA	-	Projection Algorithm
SAD	-	Sum of Absolute Different
UAV	-	Unmanned Aerial Vehicle

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background of Study**

Unmanned aerial vehicle (UAV) is an aircraft that is able to navigate without a human pilot on board. The flight is controlled by either a fully autonomous computer system or under the remote control of a pilot at some other place.

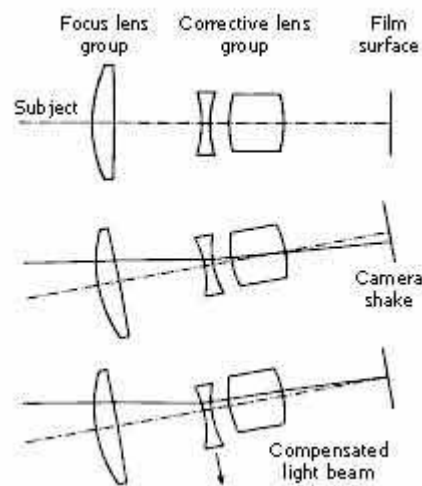
Most of the ground mapping is performed using UAV platform. The reason is that a UAV is lightweight and highly flexible and has lower cost compared to a pilot based aerial vehicle. By using UAV, human are able to navigate further and on more challenging routes. Most of the surveillance is done by using UAV.

The onboard camera plays a very important role and allows UAV to complete a lot of tasks such as area surveillance by search-and-rescue teams, tactical reconnaissance by military squads, and forest fire tracking by fire fighter [1].

One of the problems in UAV imaging is the video stability of the video captured. The vibration on board the UAV makes automatic image processing for information extraction a difficult task.

If we are able to provide good mechanical vibration absorption, then the still image captured will be sharp and focused. However, when multiple still images are captured and stitched together for a video stream, the unstable UAV will cause the video to become shaky and is hard to detect useful information.

There are numerous ways to stabilize the image being captured. Most of the compact cameras in the market today feature image stabilization mechanism. One of the methods is to provide optical feedback. By tilting one of the lenses in the camera, it will alter the optical path and make the focus beam fall back to the correct position. Hence, sharp and focused image will be able to be captured. Figure 1.1 shows the image stabilization method using optical lens compensation.



**Figure 1.1:** Image Stabilization method using optical lens compensation.

Another method, which has the same effect as the optical path alteration, is to tilt the sensor to the correct position where the image is being focused. This method requires very expensive hardware, as well as a good inertial sensor such that it is able to detect the shaking position.

On the other hand, an inexpensive way to solve the unstable image problem is by applying digital filter to the image. In still image processing, multiple images are actually captured before the shutter is released. By recombining and filtering, we are able to produce sharp and focused image as well. However, this is very subjective as we still need a good optical system before the digital filtering can work.

## 1.2 Problem Statement

When Unmanned Aerial Vehicle (UAV) is used as optical surveillance platform, there are numerous challenges. The quality of the video from UAV platform is greatly affected by the motion of the vehicle, such as unexpected roll, yaw and pitch due to the atmospheric turbulence [1]. The video stream distortion can be classified into a few categories; jitter, shaking and other unwanted movement. These distortions create difficulties in trying to extract information from the video stream. The complication further arose when we need to process the video stream by digital image processing.

The UAV airborne video can be classified based on a few characteristics. Due to the height of the UAV, the focal length of the camera used in UAV is normally having a long focal range, about 25 mm – 100 mm. When the focal length is increased, the image obtained will become relatively having a smaller visual field. The increase in focal length is needed especially to accurately identify the target objects.

There are two unintentional motions in UAV; one is due to the mechanical vibration by the UAV, and the air turbulence in the atmosphere. The mechanical vibration is a very high frequency jitter; this will increase the difficulty for the autofocus system in the camera. Whereby the air turbulence, is a low frequency swaying that pans the camera away from the targeted object of interest.

The high frequency jitter and low frequency swaying is a major problem to be fixed such that a stable video output can be captured for further analysis. There are multiple solutions for image stabilization, as discussed previously. However, we will only focus on the digital filtering approach.

When it comes to digital image processing on a small, remotely controlled platform, the resources become an extremely important factor. Some algorithms, having good performance, will always need complex computation. The high computation power yields two complications, we need more time to complete the calculation, and hence, the output becomes non-real time. Secondly, complex

computation algorithm needs high performance CPU to execute the command, in turn; it uses more power on the UAV for the image processing.

On the other hand, simple algorithm for digital image stabilization that are used by many handheld cameras / compact cameras will not solve our problem of the slow frequency swaying. Most of the digital image stabilization algorithm available on market is to compensate the camera vibration while capturing still image.

Therefore, there will be a need to study and analyze some of the widely used digital image stabilization algorithms and modify the algorithm such that it is possible to implement on UAV. Hopefully by doing so, we will be able to improve the video captured from the airborne platform.

### **1.3 Research Objectives**

In this research, we are going to study and implement a digital image stabilization algorithm by using MATLAB. By using the same software, we are going to investigate the performance of each of the algorithm that we intended to study and modify it to suite for our context, which is to be used in UAV video surveillance.

To summarize this we need to:

- i) Implement several digital image stabilization algorithms (mostly featureless) in MATLAB.
- ii) Compare the performance of these algorithms in terms of performance, code size, frame-per-second, fidelity of the image.
- iii) Tweak the algorithm such that we can obtain an algorithm that uses less computational resources yet able to stabilize the high jittering UAV video stream.

## **1.4 Scope of Project**

The project will limited the research to only focus on translation motion. Rotational movement, even it is important in UAV, is out of the scope of this project. The motion compensation algorithm will ignore rotational motion.

Besides, the algorithm to be studied will only be based on UAV implementation. That means, any video taken by moving the camera too fast will not be the target of this project. The reason is that the UAV will never move too fast or rotate too fast.

The video images are limited to only certain altitude above the ground. The research will not pay attention to video captured on ground or too high from the ground.

The project will only focus on algorithm implementation. No hardware will be involved. All performance analysis is solely based on MATLAB simulation. The exact implementation on hardware will be vary across different hardware.

Last but not least, this project is focusing on digital image stabilization by using digital filter. All mechanical or electronics based solutions are beyond the scope of the project.

## **1.5 Significance of Project**

This project will help others who need to apply digital image stabilization on UAV. Furthermore, the analysis of different algorithms and methods will be beneficial to people who intent to study on other digital image stabilization techniques. The same measure on the performance can be a guideline to those who want to implement rotational image stabilization algorithm as well.

## 1.6 Thesis Organization

This project report is organized into five chapters.

*Chapter 1* will introduce the project, brief information and scope of the project. Several previous works by other researchers is discussed here as well.

*Chapter 2* will present literature review and details about the information and scope of the project. Some information on MATLAB image processing toolbox that is being used in this project is discussed in this chapter.

*Chapter 3* contains the methodology and implementation for the project. This chapter specifically shows the algorithm and theories that are used in this project. All implementation of the module will be discussed here.

*Chapter 4* presents the results and discussion of this work. All results from the previous algorithms will be presented here. The detailed analyses of the results are discussed too.

*Chapter 5* concludes this work. Future recommendation works are suggested and explained.



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