Camera Body Incorporating a Movable Focal Plane Array

Final Project Requirements

1. Introduction

Imaging systems are always subject to mechanical disturbances. They move because they are held by a person, or mounted on a moving vehicle. The structures they are mounted to are subject to mechanical vibration. If the angular motion of the camera over an integration time is comparable to the instantaneous field-of-view of a pixel, then the image will be smeared. (Fasse, 2008)

In general, image motion compensation refers to active control of something (optical element position, focal plane position, index of refraction, surface curvatures, etc) to stabilize the object space line-of-sight (LOS) of the focal plane array (FPA). The goal is to compensate for unwanted motions of the camera. This requires measuring that motion using some sort of gyroscope or other motion sensor.

There are four more-or-less common methods of compensating for image motion:

1. Moving the entire optical system
2. Moving the focal plane array
3. Adding a flat, fast steering mirror (FSM)
4. Moving optical groups

The second method, moving the focal plane array, is being investigated for this project. In particular we consider the mechanism used by Ricoh Caplio, which is shown schematically in Figure 1.

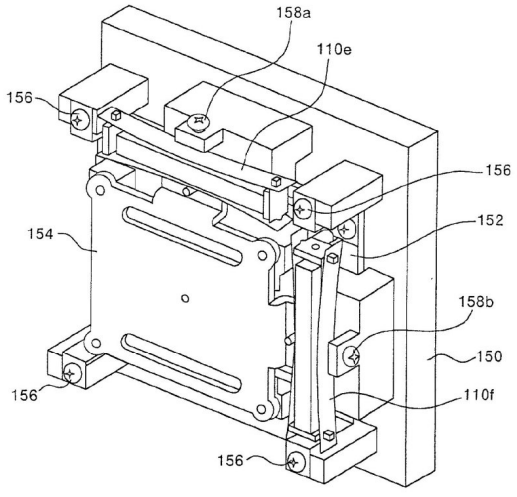

Figure 1: Schematic of focal plane array mechanism (Kitazawa, et al., 2002)

Designing a complete camera with stabilized focal plane array would be too large a scope given the available time. Thus the scope is restricted to the design of the mechanisms, without regard for sensors

and actuators. Indeed, part of the goal of the project is to come up with requirements for the sensors and actuators.

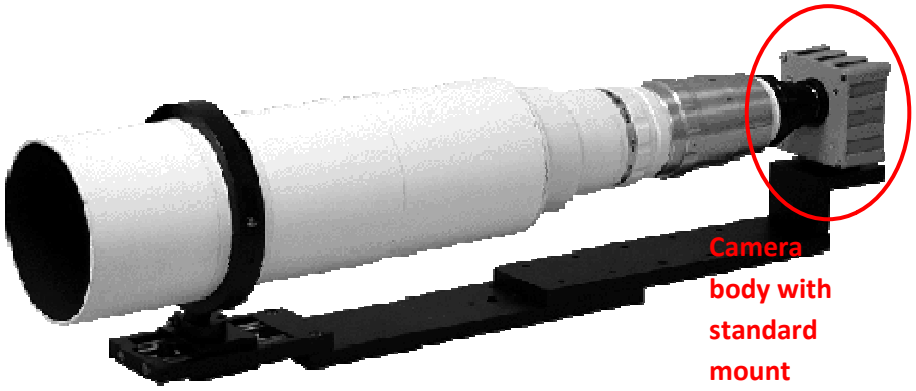

Figure 2: A camera body attached to a telephoto lens with a standard mount (Visual Instrumentation Corporation, 2009)

Just to be clear, only the design of the camera body will be considered. The body must be compatible with a standard lens, as illustrated in Figure 2.

2. Requirements

The goal of this project is to design a camera body incorporating a movable focal plane array. The following requirements must be met.

- The body must include a mounting feature that is compatible with commercial, off-the-shelf (COTS) lenses. The class of lenses chosen (e.g. C-mount, F-mount, four-thirds) must include a focal length of at least 400 mm, with a speed of f/5.6 or faster.
- The sensor platform must be large enough to mount so-called full frame (35 mm) format FPA's.
- A specific FPA must be chosen as an example. This FPA need not be a full frame FPA.
- The FPA chosen must be part of a system that can be interfaced to a computer without a lot of electrical system design. For example, it could be part of a system with an IEEE-1394 (Firewire) interface. It could be part of a system that interfaced with a commercial frame grabber.
- The specific FPA and associated lenses should operate in the visible spectrum. This will keep development and test costs low. The design should not preclude other spectra, particularly in the infrared.
- The FPA should have a minimum frame rate of 15 frames per second.
- The FPA should have at least VGA resolution. There is no pixel pitch requirement per se, but smaller pitches are preferred for evaluation purposes.
- The sensor platform mechanism must allow for two translational degrees-of-freedom (DOF). No rotational DOF is required.

- The range of motion of the platform mechanism should correspond to a 1 mrad change of line-of-sight (LOS) at a focal length of 400 mm.[1]
- The operational temperature range is 0—40 C.
- The focus and tilt of the focal plane need to be controlled and/or adjustable.[2]
- The system needs to survive a 20 G shock

Additionally, the following analysis is required:

- Must come up with an actuator force requirement to accelerate the platform at 10 G.

3. Works Cited

Fasse, E. D. (2008). *Image Motion Compensation: A tutorial including analysis of a catadioptric ultra-telephoto lens.* Retrieved March 9, 2009, from UA Optomechanics: http://www.optics.arizona.edu/optomech/student%20reports/tutorials/2008/Fasse_521_IMC_Tutorial.pdf

Kitazawa, T., Kitaguchi, T., Shimizu, H., Katoh, M., Sato, Y., Sasaki, S., et al. (2002). *Patent No. US 2002/0163581 A1.* USA.

Visual Instrumentation Corporation. (2009). *Lenses for High Speed Cameras and Video Systems*. Retrieved March 10, 2009, from http://www.visinst.com/Lenses.html

[1] This is a somewhat arbitrary requirement (straw man). It is not clear if this requirement can be met but it will serve as a guide for design.

[2] Need some more specific requirements, but am not yet sure what they should be.