CENIIT Final Report:
Virtual Global Shutters for CMOS Cameras

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1 Introduction

This is the final report for the CENIIT project "Virtual Global Shutters for CMOS Cameras". The project started January 2009 and ended December 2014.

1.1 Background

Most video capable consumer products sold today (e.g. cellphones, tablets and camcorders) are equipped with CMOS sensors. Compared to the conventional CCD sensors, a CMOS sensor is cheaper to manufacture, and is easier to integrate with on-chip processing [3]. CMOS sensors, by design make use of what is known as a *rolling shutter* (RS). In an RS camera, the image is read out from the sensor one row at a time, and thus each row is exposed during a slightly different time interval. The more conventional CCD sensors on the other hand use a *global shutter* (GS), where all pixels are read and reset simultaneously. Since image rows on an RS camera are acquired at different points in time, motion of either camera or target will cause geometric distortions in the acquired images. See figure 1 for an example of geometric distortions caused by using an RS.

1.2 Project Perspectives

The long term goal of this project has been to make rolling shutter cameras more useful in situations where they are currently used, and also to open up entirely new uses for them. To this end we have designed image rectification algorithms that aim to convert rolling shutter video to global shutter video, see figure 1. We have also studied camera motion modelling and scattered data interpolation.

The project continues in the form of a newly granted VR project for *Learnable Camera Motion Models*.

Figure 1: Image acquired during camera rotation on a rolling shutter cell-phone. Left: Video frame from iPhone3GS. Right: Rectification from our CVPR10 algorithm.

2 Scientific Results

The results that have had the most impact this far has been the image based rectification algorithms described in [2, 14], and the inertial sensor based rectification in [5]. Both algorithms are able to convert video from a rolling shutter camera to corresponding global shutter video.

The structure from motion technique described in [6] has also gained broad interest, and several research groups are now publishing adaptations and extensions of the proposed algorithms.

Other research results from the project include push-broom image rectification and subsequent change detection in pushbroom imagery [12, 13], rectification of RGB-D sensor data [16], and scattered data interpolation [21]. Most recently we have developed video stacking techniques that allow sharp images to be taken on cell phones in low light conditions [19].

3 Degrees and promotions

The project has resulted in the following scientific degrees and promotions:

1. Licentiate degree for Erik Ringaby [10]
2. PhD degree for Erik Ringaby [11].
3. Associate professor (Universitetslektor, Docent) promotion for Per-Erik Forssén.

4 Master's Theses

The project has resulted in two master's theses [4, 1].

5 Funded staff

The project has mainly funded the PhD studies of Erik Ringaby. The two master students Niklas Forslöw and Gustav Hanning also received funding during their respective summer internships. Due to limited amount of resources, the PI, Per-Erik Forssén has been funded from other sources, and the project has only funded one of his conference trips.

6 Industrial Contacts

The scope of the project was initially developed in cooperation with the industrial partner, Saab Dynamics (SBD) in Linköping. Contact: Leif Haglund. SBD has provided data for evaluation of the developed algorithms, and participated at project meetings. We have also held a Computer Vision course at the Saab premises where we disseminated results from this project and computer vision in general.

We have also collaborated with the Swedish Defence Research establishment (FOI). Contacts: Jörgen Ahlberg, and Ola Friman. Together with FOI we have studied push-broom image rectification, and change detection in push-broom imagery. We have also conducted a big evaluation of scattered data interpolation techniques for push-broom sensors, using datasets provided by both FOI, and FFI, its Norwegian counterpart.

These studies were financed by FOI, and have thus helped to fund the project. This source of supplementary funding was approved by the CENIIT board.

With the help of the Innovation Office at Linköping University, we have also started a company of our own, FR Vision AB. The company has been awarded a US patent on the rectification and stabilisation process described in [14], and currently markets and sells a cell-phone app that implements the algorithm on iOS devices.

Over the years, we have also been in contact with several other companies, including Intuitive Aerial AB, Parrot Inc., and Spotscale AB.

7 Contacts with Other CENIIT Projects

None.

8 New Research Group

The PI is currently employed as Associate Professor (Universitetslektor, Docent) at the Computer Vision Laboratory, which is headed by Prof. Michael Felsberg. At the lab the PI currently manages several research projects, of which one is a direct continuation of the CENIIT project. He currently supervises three PhD students.

9 Publications and Patents

In total, the project has resulted in two articles in scientific journals [14, 21], six peer reviewed conference publications [2, 16, 5, 8, 6, 19], seven national conference presentations [9, 12, 15, 17, 7, 20, 18]. Of these, one received a best paper award [5], and one recevied the conference industry prize [18].

The project has also resulted in two masters theses [4, 1] one licentiate thesis [10] and one PhD Thesis [11].

Finally, the project has resulted in the US patent "SYSTEM AND METHOD FOR VIDEO STABILIZATION OF ROLLING SHUTTER CAMERAS", P.-E. Forssén, E. Ringaby US Patent App. 13/081,534.

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