VisionMap Sensors and Processing Roadmap

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ABSTRACT

The A3 is a family of digital aerial mapping cameras and photogrammetric processing systems, which is based on two main technologies: (a) fast scanning optics that enable high resolution capture of very large areas in a wide field of view, and (b) total automation of photogrammetric processing for very large projects.
One of the most inetersting features of the technology is its scalability: A3's sensor architecture can be scaled substantially, using off-the-shelf detectors, in comparison to some of the other architectures in use.
During the past years, A3 systems have been used in some of the biggest and most challenging projects worldwide. The knowledge gained throughout this period has enabled us to substantially improve the performance of the A3 family.
A3 Edge is the new model in the A3 family, which provides dramatically better image quality, an even higher GSD than other A3 models and even higher efficiency. Another development that's aimed at increasing capture efficiency is better stabilization of aircraft movements which reduces excessive frame overlaps. This can generate an improvement of tens of percentages in coverage efficiency in various scenarios. In addition, four band performance has been greatly improved over previous generations.
Moreover, with A3 Edge it is possible to know, within minutes after touchdown (and using no servers), that all the imagery planned for the flight was in fact captured in high quality and that no re-flying will be required.
A3 LightSpeed is VisionMap's automatic processing system. It automatically performs aerial triangulation and produces orhtophotos, stereo pairs and DSM from all A3 cameras. LightSpeed has been made faster and more scalable.
Another direction in which VisionMap is investing heavily is automatic 3D modeling. The unique features of A3 imagery are well suited to 3D modeling: simultaneous nadir and oblique imagery in very high resolution, available in a multitude of angles for each object, coupled with a very strong geometry.

This paper will review the improvements we have made to A3 as well as VisionMap's near future roadmap for the A3 camera and processing system.

1. INTRODUCTION TO VISIONMAP

VisionMap is a leading provider of digital automatic aerial survey and mapping systems. VisionMap’s innovative data acquisition and data processing system optimizes mapping work and creates new opportunities for our business partners. VisionMap's technology empowers aerial survey providers to capture larger areas in higher resolutions, at varying altitudes in accordance with air traffic constraints, without compromising on high resolution and high accuracy photogram-metric products. Our integral, fully automatic and highly-efficient processing system enables mapping providers to deliver top grade products in less time and with substantial reduction in operational and processing costs.

Figure 1: A3 view from below the aircraft.

2. A3 PRODUCT FAMILY

2.1. A3 Technology Overview

The A3 family is a family of digital aerial cameras and photogrammetric processing systems. The camera is mounted on the plane so that the sweep axis is along the fuselage (which is the flight direction). The two lenses of the camera sweep simultaneously across the flight direction from one side to the opposite side and take pictures at a very rapid rate that can reach 64 frames per sweep, amounting to a maximum of 594 megapixels per sweep.

Each telescope consists of a folded lens, which includes an innovative patented motion compensation mechanism. The motion compensation mechanism moves the secondary mirror in the folded lens telescope in order to compensate for forward motion, for the sweeping (roll) motion and for whatever vibrations survived the suspension.
Each telescope has 300mm focal length, providing a very high GSD at even high altitudes.
The sweeping mechanism generates a wide field of view (up to 109°) and enables capturing both nadir and oblique images in one flight by one camera, providing ideal data for 3D products, as well as strong angles for photogrammetry.

See illustration below:

Figure 2: A3 unique capture illustration.

2.2. A3 Edge Improvements

Edge is the new model in the A3 family. It provides much better image quality, an even higher GSD than other A3 models and even higher efficiency.

The improvements in performance are reached by utilizing (a) a new CCD (KODAK KAI-16070), (b) a new over-sampling technique that provides more sharpness and reduces noise in the image, (c) a stronger motor with acceleration of 15 rad/sec^2, and (d) better stabilization achieved through better software and an optional stabilized mount.

Figure 3: A3 Edge.

The original design of Edge utilized the KODAK KAI-29050 (pixel size of 5.5um), whereas the newest configuration utilizes the KODAK KAI-16070 (7.4um pixel size). The KODAK KAI-16070 was chosen due to the larger pixel size which helps to increase the

light gathering capability of the pixel by 80%, improving signal-to-noise and low light performance. In addition, smear rejection has been improved by 4x (to -115 dB), dynamic range has been doubled, and blooming suppression has been increased to over 1000x.

The KAI-16070 supports full resolution readout at up to eight frames per second. This enables the dual CCD Edge to collect imagery at a maximum rate of 256 megapixels per second, compared to previous generations of A3 that were limited to 160 megapixels per second.

The extra pixel count coupled with the smaller pixel size enables the design to provide much better GSD and capture efficiency. However, the designers decided to invest some of the extra pixel count in smart oversampling of the image. Edge oversamples by 20% in each image direction meaning that the actual increase in pixel size we achieved is a very significant 44%. This improves the signal to noise ratio of the image significantly. In addition, all noise introduced by the Bayer filter is effectively removed this way and the result is a very a high quality image with better color resolution than architectures that utilize pan-sharpening methods.

See A3 Edge specification summary below:

Sensor technical data	
Sensor CCD	KODAK KAI-160
Pixel size (micron)	7.4
Focal length (mm)	300
Frame rate (FPS)	8
Single frame size (pix)	4,864 * 3,232
Max footprint (pix)	80,000 * 10,000
Cross track FOV (deg)	109
Along track FOV (deg)	13.5
Color	RGB (CIR also available)
CCD dynamic range (bit)	12
Motion compensation	Forward, Roll, Vibration (FMC,RMC,VC)
Flight operational data	
Total weight (Kg)	42
Camera dimensions (cm)	50*60*60
Operating temperatures (deg, C)	-15 to 55
GPS	L1/L2
Power Consumption	26-32
Peak Current	Typical: 5, Peak: 10

Table 1: A3 Edge specification summary.

As you can see in the table below, A3 Edge with KAI-16070 also provides a vast improvement in efficiency and productivity.

Ortho GSD (cm)	GSD	5	10	15	20	25	30
Altitude above ground (ft)	H	5,542	11,084	16,626	22,168	27,709	33,251
Ground Speed (knot)	V	160	250	290	360	430	490
Effective angle (deg)	2α	25	35	50	55	60	65
Distance between Flight Lines (m)	Dv	712	2,024	4,490	6,683	9,265	12,268
Sweep Width (SLF,m)	W1s	1,658	4,558	10,030	15,129	20,575	27,364
Aerial Survey Productivity (ortho coverage, sq.km/hour)	COV4	211	937	2,411	4,456	7,378	11,133

Table 2: A3 Edge aerial productivity.

Comments:
1. Forward overlap – 55%, Side overlap – above 55% ;
2. 2α – an effective angle of a full FOV used for orthophoto production;
3. 2α=65° corresponds to 20% side overlap for RC30 camera with F=150 mm;
4. The parameters above were calculated for A3 EDGE/S model with gyro stabilized mount.

2.3. Increasing Efficiency Using Better Stabilization

Better motors and stabilization in Edge enable the system to scan in higher accelerations, providing better coverage performance. Utilization of a stabilized mount improves the performance of Edge CIR configuration by 20% in certain scenarios.

2.4. Versatility

A3 Edge is suitable for various applications and flight altitudes. For example, in order to acquire 15 cm GSD imagery, the user can choose to fly in an altitude anywhere between 5,500 to 16,620 feet, maintaining a field of view of at least 65° in all altitudes. Thus, the user may fly low when constrained by weather, or very high when possible, providing incredible productivity.
For example, at 16,620 feet, A3 Edge supports a ground speed of 350 knots, yielding 2,270 square kilometers of orthophoto per hour of flying (assuming a 2α orthophoto angle of 40°). Thus, Edge provides a very flexible capability to efficiently acquire high resolution imagery in variable atmospheric conditions and aviation constraints.
An additional way to describe A3 Edge versatility is that it can be used for applications of narrow angle cameras, wide angle cameras and even super-wide angle cameras.
Finally, A3 Edge can capture both nadir and oblique images in a single flight and process them to a single photogrammetric block using LightSpeed software.

3. A3 LIGHTSPEED PROCESSING SYSTEM

A3 LightSpeed is VisionMap's automatic processing system. It automatically performs aerial triangulation and produces orhtophotos, stereo pairs and DSM from all A3 cameras.
A3 LightSpeed is able to process an incredibly large amount of imagery, which only grows as VisionMap users take on larger and larger projects. Last year one of VisionMap's users captured around 5,000,000 frames in a single project. For the standard cluster configuration the single aerial

triangulation block can consist of up to 250,000 images which for 25 cm GSD will cover the area of 36,000 sq.km for orthophoto production.
LightSpeed version 3.4 optimizes the processing of four-band CIR products.

4. FLIGHT VIEWER

One of the challenges in image acquisition, more so in larger projects, is that acquisition is performed out in the field, whereas image processing is performed very far away, in the office. For this reason it is vital to be able to analyze the imagery out in the field, to ensure that any problem in the data is known while the aircraft and aviation team are still in the capture area. Based on our experience in capturing very large areas, VisionMap has identified this need and recently developed an application named Flight Viewer. This application enables quality control immediately after the flight on any laptop, without the need for processing hardware. Flight Viewer rapidly creates a mosaic of all acquired data and full resolution frames can be selected and viewed minutes after the flight. Using the Flight Viewer, the camera operator can identify areas that require re-flights immediately. See screen shot below:

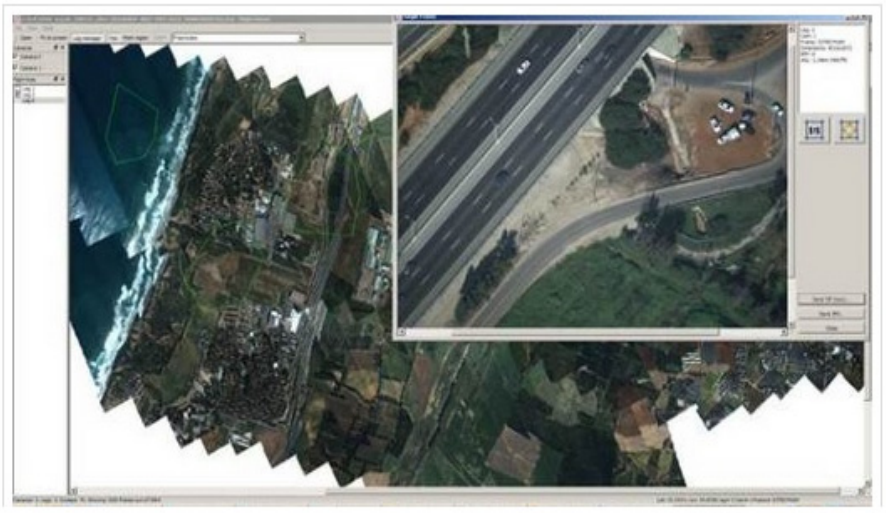

Figure 4: Flight Viewer screen shot.

The application is very simple to use and supports the A3 camera family. Additional features that are available are exporting SHP files to external software and exporting a small preview file of the flight in order to share with the project team.

5. 3D

In the last couple of years the use of aerial photogrammetry techniques to generate 3D models has become a trend in the geospatial industry. The demand for 3D geospatial data is expanding and technology is evolving at an unprecedented pace. VisionMap's A3 family is ideal for such 3D applications, as it provides high resolution wide field of view imagery, with varying angles and high geometric stability.

VisionMap has been exploring technologies for 3D image reconstruction in the past years. Recently a dense point cloud was computed from a high resolution multi-view A3 image block was created using an IFP semi global matching algorithm. The density of generated DSM was 6 cm

(~260 points per sq.m) with a precision (average standard deviation of depth estimation) of 4.09cm, which was achieved when all stereo models were included.

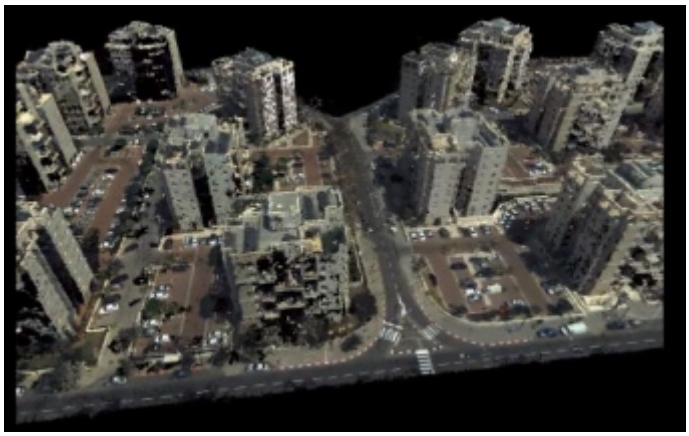

Figure 5: Point cloud generated using SGM.

A3 and LightSpeed have been integrated with 3rd party software that enable automated 3D model extraction, quickly and in high quality.
VisionMap is working on further optimization of 3D modeling with its partners and R&D team.

Figure 6: Photorealistic 3D automatic texturing with A3 images and Acute 3D engine.

6. CONCLUSIONS

VisionMap's technology has always shown spectacular performance in terms of area coverage efficiencies and high resolution capture and processing. The practical knowledge gained by working with our partners during the past years, in addition to innovation in the CCD industry, have enabled us to greatly improve other aspects of the technology, such as image quality, quality control and processing speed, making A3 Edge and LightSpeed a uniquely capable technology.

7. REFERENCES

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