Georeferencing of hot spots onto solar panels for inspection purpose

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Highlights: This paper gives an overview of the effectiveness of UAV inspection and aerial data post-processing in the field of solar panel optimization. The georeferencing of infrared and radiometric information onto large solar farm maps helps maintenance operations and improves both the security and the efficiency of the process.

Key words: *georeferencing, inspection, solar panel, hot spot, maintenance*

Introduction

AIR MARINE is a company specialized in delivering enhanced information with the best layout available. Those data are gathered by aerial means such as UAVs and processed to give added value to the report. This method is also applied to topographic and structure inspection missions.

This article focuses on the inspection of solar panels. Operating and maintaining solar farms, especially large ones, is time consuming, possibly dangerous and costly. Thanks to the eye of the drone and the valorisation of the data, AIR MARINE is giving the appropriate tools to maintenance experts to work more efficiently. The aim is to provide inspection maps that georeference and characterize the hot spots in order to better target the follow-up actions.

AIR MARINE is using a thermal imager and a radiometric camera mounted onto a state of the art UAV able to perform preprogramed flight. The company has developed a method to acquire and render turnkey aerial data. The following content presents the results of its experience so far and discusses future evolutions. The inspection of solar panels by UAV is thus at the same time very interesting and representative of the issues of facing large data processing.

Material and method

Sensors

AIR MARINE uses either a thermal imager or a radiometric camera depending on the customers' needs. It owns a dedicated solution combining a sensor and a software designed by the Italian company PANOPTES especially for solar panel inspection. The solution is named mT-Panoptes. The sensor has two channels: one in infrared from a FLIR TAU 640 and one in the visible spectrum thanks to a photo camera. The infrared camera has the advantage of implementing its data into a so-called SOLAR INSPECTOR software. This software automatically georeferences the hot spots discovered in the workflow in real time. In order to do so, the user has to implement a georeferenced map of the solar farm. Existing maps can be used or a new one can be built thanks to a previous aerial RGB pictures acquisition and a photogrammetric post-processing.

Figure 1: The bi-sensor TIR and VIS mT-Panoptes, part a dedicated solar panel inspection solution

	FEATURE	THERMAL IMAGER	VISIBLE LIGHT IMAGER
Detector	Detector	Uncooled micro bolometer	CMOS sensor
	Optical Format	(4:3)	16/9
	Resolution	640 (H) x 512 (V); 324 (H) x 256 (V)	1280 (H) x 720 (W)
	Pixel size	17 µm x 17 µm	-
	Frame rate	9 Hz	30-60 fps
	Temp. measur. range	-40 °C to 160 °C (High Gain) -40 °C to 550 °C (Low Gain)	-
	Temp. meas. accuracy	± 0.2 °C	-
	Lens and View angle	13 mm F 1.25 / 45°; 9 mm F 1.25 / 48°	- / 142°
	Sensivity	< 50 mK (NEdT)	
	Spectral response	7 – 13.5 µm	Visible range
Data	Output	PAL / NTSC video	PAL / NTSC video
Physical	Dimensions	76 x 52 x 60 mm	
	Weight	From 260 to 600 g, depending by the integration mode	

Figure 2: Features of the hardware mT-Panoptes

The key issue lies in being able to know the exact position of the hot spot on the solar panel (definition of the row, string etc.). This information helps gain effectiveness on the ground, saves time and optimizes the maintenance cost.

Some additional information can improve the report. The infrared images from the thermal imager show contrasts of temperature. On one hand, an abnormal hot spot compared to the average temperature of the panel may be the cause of a dysfunction that is both reducing the global electricity production and is potentially a threat to the integrity of the panel (risk of fire). On the other hand, a surface showing a very low temperature in the colour scale of the sensor is also an operating loss. Those comparisons give clues to what the cause of the abnormality might be and show direction in the maintenance process. An added data giving the temperature of the core spot can help characterizing the deficiency and its geographical origin: panel itself, row, column, converter etc. It can also have various implications for insurance purposes. Indeed, insurance companies sometimes require a certain temperature disparity to apply. For those reasons, the use of a radiometric sensor might also be useful.

AIR MARINE is using the light-weighted OPTRIS PI 450 which benefits from a radiometric flow. It has a strong thermal sensitivity that allows for the detection of small temperature differences. It acquires thermal images displaying temperature measurement on each single pixel. The camera also has a high sample frequency as well as a good resolution. It helps maintaining good operation performance without being too heavy. The temperature range that can be measured lies between -20°C and 900°C.

Figure 3: The radiometric camera OPTRIS PI450

Operation and processing chain

Depending on the level of precision that needs to be achieved, AIR MARINE defines a preprogramed flight. It uses reliable and enduring UAVs capable of acquiring large amount of data in a short time. To get the best performances of those UAVs, the telepilots apply various levels of speed, altitude and camera calibration to adjust their flight plan.

Usually, solar farms are located in non-populated areas which correspond to scenarii in the UAV French regulation. It is then permitted to use the md4-1000 from the German brand MICRODRONES, which is a reliable and stable quadrirotors. This drone is well known for its unique payload/endurance ratio. It carries 1,2 kg for an operating time of 35 to 40 minutes.

Figure 4: Telepilots deploying their material MICRODRONES md4-1000

It is crucial to listen and understand the needs of solar plant manager to build up on his competencies. First, AIR MARINE discusses back and forth with the client and translates what needs to be done to the operational team. Internally, telepilots in charge of the acquisition work together with the post-processing team to ensure that the capture will achieve an optimal deliverable. Those interactions allow for a final report that responds to high quality standards fulfilled by AIR MARINE.

Figure 5: Flight plan example

The processing team consists of experts in infrared data and geomatics. They are involved in the process at different steps. They are in charge of creating the georeferenced map of the solar farm -when needed- and of programing the software SOLAR INSPECTOR prior to the acquisition. They can use a photo acquisition along with the GPS tags from the drone and sometimes ground control points. After the flight in infrared, they generate the report from the software georeferencing the hot spots. They improve it with annotations concerning the defaults, suggestion on the origins and use a classification for the level of danger that can correspond to the client's classification. When a radiometric acquisition is made, complementary temperature data can be extracted from the video thanks to the software PI CONNECT from OPTRIS and put them together in a report. Either method can be used, or both types of acquisitions can be merged together.

Results and discussion

Mapping

AIR MARINE is able to provide maps with a precision up to 3 centimetres which is precise enough to get the position of the defaults on the panel. This service addresses a real need from the solar farms managers and is

aimed to increase the energy efficiency. It is possible to map an entire solar farm in a really short time (up to 100 ha in one day) and acquire compelling information that could be used on the ground. It takes part in the chain of decision and extends the lifespan of the solar panels.

The traditional methods in use induce sampling actions carried out by the owner that are at the same time tedious and non-specific. Inspecting solar panels by UAV allows maintenance team to document and prioritize corrective actions, instead of deducing the global state of the system.

The OPTRIS software PI CONNECT is used to calibrate the radiometric camera OPTRIS PI 450 and to manage the data in post-processing. It is possible to extract images from the video and numerous features allow an in-depth analysis.

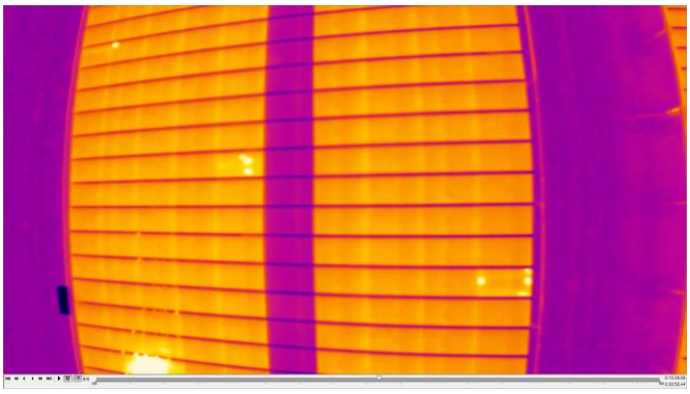

Figure 6: Infrared image of hot spots on solar panels in the OPTRIS software PI CONNECT

Georeferencing

Though the needs of the customer are well covered by the existing solution and gives appropriate results, the process could be improved. The use of different sensors with various capabilities lengthens the time of acquisition. It is a technological challenge but if it were possible to georeferenced a radiometric flow, the final report could be improved and time saved.

Another mean of development is the industrialization of the whole process from the understanding of the requirements specification from the client to the delivery of the processed data. AIR MARINE is standardizing its procedures in order be able to duplicate its interventions on a higher level, still delivering same high standards of quality. The company is specialized in operating UAVs and processing data at controlled costs.

The software SOLAR INSPECTOR is based on a GIS engine that enables a full spatial management of the surveys. It is a complete solution that is used during the acquisition and in the post-processing. It displays the flight information from the UAV gathered by the telemetry directly in the base station as well as the map of the capture, the video, the timeline and an area to take notes.

Figure 7. Hotspots map obtained with the software SOLAR INSPECTOR from PANOPTES

Conclusion

Georeferencing hot spots onto solar panels for inspection purpose is a good representative example of the issues faced by data acquisition by UAV and its valorisation.

On such other subjects as topography or structure inspection, AIR MARINE applies the same comprehensive method to reach a well ordered procedure that will provide the accurate processed data.