Abstract Booklet of the 14th edition of the

International Workshop on Advanced Infrared Technology and Applications, AITA 2017

and of the 8th **IWASPNDE WORKSHOP**

Sept. 27th - Sept 29th, 2017, Québec City (Canada)

AITA 2017

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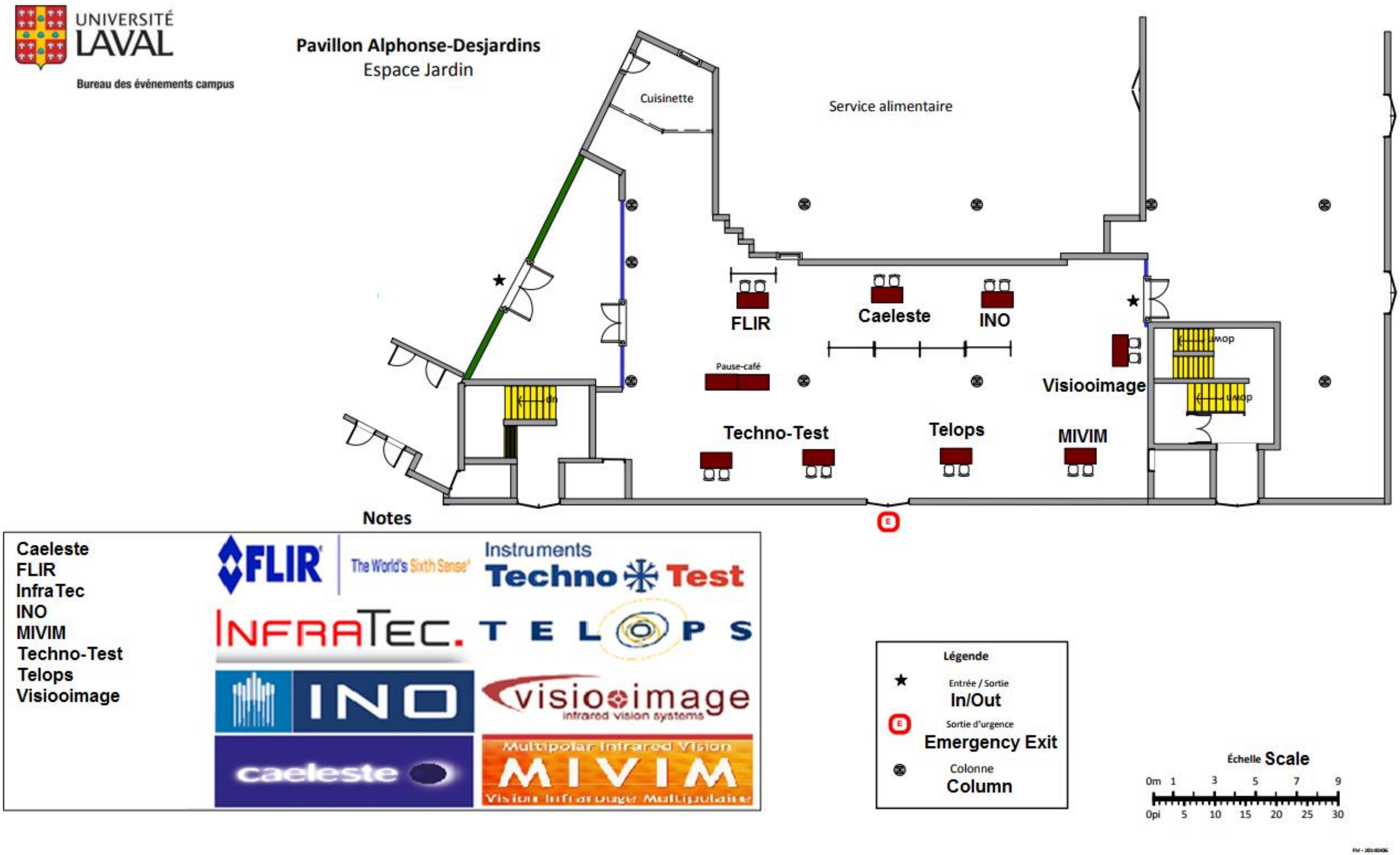
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Preface

It is our pleasure to welcome you here at Université Laval for the 14th edition of the International Workshop on *Advanced Infrared Technology and Applications,* AITA 2017!

AITA Workshops were born in Italy were most of the Editions took place. In 2007, AITA was hosted in León, Mexico by Prof. Marija Strojnik. Hence, to mark this 10th anniversary, the Program Committee decided to organize AITA 2017 once again in North America, but this time in Quebec City, Canada.

Interestingly 2017 marks also the 150 anniversary of the Canadian Confederation with all kind of celebrations all across the country so it is a unique opportunity to host AITA right here in Canada!

AITA is a forum that brings together researchers in the field of infrared science and technology to exchange knowledge and ideas. Interestingly, the VIIIth edition of the *International Workshop on Advances Signal Processing for NonDestructive Evaluation* (IWASPNDE, Quebec Workshops) will take place as a simultaneous event.

For the 2017 edition, sessions were divided as follows: Applications, Detectors, Environment, Image processing*, Medical, NonDestructive Testing*, Techniques, Thermal properties, and we also have an invited session organized by Prof. A. Mandelis: Biothermophotonics (*: joint sessions with *VIIIth IWASPNDE*).

The following invited Keynote Lectures are others program highlights:

• «IR thermography applied to assess thermophysical properties of Thermal Barrier Coatings», Dr. Paolo Bison, CNR - ITC, Italy;
• «Cultural Heritage, an IR Perspective», Dr. Roman Maev and Dr. Dmitry Gavrilov, University of Windsor, Canada;
• «Photothermal Coherence Tomography (PCT): «Principals and Non-Invasive Biomedical, Dental and Engineering Materials NDI Applications »
Dr. Andreas Mandelis, University of Toronto, Canada.

The «Under 35 Paper Award» competition will take place during the Workshop. This Award is named after Ermanno Grinzato who passed away in 2012. Mr. Grinzato was AITA cochairman for a long time and was a very well-known scientist in the thermography community. Additional Workshop highlights are a Poster session, a Vendor Session, an Exhibit with the following Companies participating: Caeleste, FLIR, InfraTec, INO, TechnoTest, Telops, Visioo-Image.

The social program includes a Reception and a Visit, Cocktail and Banquet at «Aquarium de Québec». For this last event, we thank Telops for their generous support.

As usual, a selection of the received papers will be published in a peer-review journal: *OSA Applied Optics*.

Finally, the website: `http://aita2017.gel.ulaval.ca` will be maintained active for future references. The website includes the Workshop Booklet with all the abstracts in .PDF format. This way to proceed was found more convenient and environmentally friendly.

As partners in the success of this week, was the help of the Program Committee, Scientific Committee, Organizing Committee, Université Laval, including my own Electrical and Computing Engineering Department and staff. The participation of our exhibitors is also appreciated. I would like also to point out the dedicated work of all our student staff and particularly of our assistant, Mr. Patrick Deschênes Labrie.

I will conclude these remarks by wishing to all a fruitful Workshop, full with great talks, great discussions, meetings of old and new faces! I would like also to thank you all for your participation which is essential to the success of AITA 2017.

Enjoy AITA 2017, enjoy beautiful Québec City, Canada!

Xavier Maldague
Chair, AITA 2017

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POWER LINES INSPECTION VIA RGB, THERMAL AND INFRARED IMAGING

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Image processing, applied to visible and infrared thermal data, is used to detect faults and anomalies in power transmission lines. Recently, Unmanned Aerial Vehicles, equipped with infrared or visible cameras, are used in urban or rural areas to acquire data, useful to comprehensively inspect the status of the infrastructure. This paper provides a concise review about vision-based algorithms used for the inspection of electric power lines, with a specific focus on methods and technologies which are suitable to be implemented in a UAV-based monitoring system of infrastructure for the transmission and distribution of the electric power.

Introduction

Power transmission lines are the means of electricity distribution and it is of extreme importance to ensure their continuous supply and high performance. At the same time, defect detection at an early stage not only can save the life of the system but also the operational cost. In addition to that, it can save the damages and can predict future anomalies too. Therefore, the continuous surveillance and inspection of power lines can play a vital role to ensure the continuous electric transmission. Much research on how to improve the power line detection methods and inspection's efficiency has been developed for a long time. In this paper, we will present different studies based on these methods using visible and thermal imaging cameras. The main focus will remain at the inspections via UAVs. We will highlight the different aspects of the methods used for the detection and inspection of power lines. We will also discuss different computer vision methods used to analyze visible and infrared image data. Before presenting these methods, we will first briefly introduce different modes of inspection.

Inspection modes

The most widely used method to inspect power lines is the foot patrolling: a team of personnel inspects the lines by or with the ground vehicle. The team is equipped with binoculars, and/or visible and infrared cameras, however this process is relatively tedious and long. As an alternative to foot patrolling the inspection may be performed using a manned aerial vehicle, e.g. a helicopter equipped with visible or infrared cameras, hence acquiring images of conductors and insulators from high above the power lines. Then, data are either manually inspected, or automatically processed for the fault detection. This method is faster but usually more expensive. Also, when a fault is detected, skilled operators are required to climb in order to check and eventually fix the damage. In order to reduce the operational cost, climbing robots came up as an alternative solution. The climbing robot travels along the conductors, achieving similar speed as in helicopter assisted inspection. In comparison to the foot patrolling, often requiring climbing on the power lines, the climbing robot is a safer and not time consuming solution. Although having specific benefits, climbing robots are still not a practical solution to inspect the huge network of distribution lines [1].

Over the recent years UAVs are being used for a wide spectrum of applications, supporting humans in dangerous and challenging environments, including the inspection and maintenance of power equipment. Modern flight control technique and image processing allow UAVs to carry out fast inspection from some distance. Based on GPS data of both the UAV and the electric towers, the embedded algorithms are able to perform the automatic tracking of power lines. Compared with the conventional inspection methods, UAV-based inspection is more advanced, less expensive and safer. However, UAVs and manned aerial vehicles share some common problems, occurring while monitoring the power lines: camera stabilization, pole tracking and automatic detection of defects. The acquired data, generally a sequence of images, are analysed by the operator to assess the maintenance status of the power line. In the infrastructure monitoring by UAV, the challenge is to make the inspection fully automatic and almost real-time, by using proper statistical and morphological processing techniques to highlight the hot spot in cables and insulators.

Vision-based methods

Power line inspection can be done by using visible or infrared camera. Thermal and infrared imaging has gained recognitions in the field of power systems during the last two decades. It has been used for testing and inspection of different electric parts and also for preventive maintenance work. Recently, UAV-based inspection systems are used to comprehensively inspect power transmission line in urban and rural areas. Here we focus on image processing methods used to analyse both visible and infrared images. In both cases, the acquired data is a sequence of 2D image of the scene. In this scene, the background could be green fields, water, mountains or buildings. Therefore, in order to investigate the condition of the lines, the very first step is to identify the power lines in the images. Detecting power lines from a cluttered background is one of the most important and challenging tasks. In general, all methods follow the two step process. i) Identify expected power lines and remove rest of the background. ii) Connect the expected power lines and remove unwanted straight lines. In the following sections there is a brief description of image type, along with a discussion of the methods used to identify and inspect power lines.

Processing of thermal-infrared data

Infrared thermography uses infrared sensors to capture images of thermal objects based on temperature variations. Generally, thermal imaging is considered as a robust, non-destructive and contactless methodology to inspect power lines, as the inspection can be performed by keeping some distance, hence there is no need to halt or cut down electric supply during the inspection.

Hongwei et al. [2] had presented a fusion algorithm for the infrared and visible power lines image. They extracted the SIFT features from the images and calculated the optimal homograph matrix to fuse the visible and infrared images by bicubic interpolation algorithm. Their method is invariant to large scale changes and illumination changes in the real operating environment of power equipment. Similarly, Larrauri et al. [3] identified areas of vegetation, trees and buildings close to power lines and calculated their distance from power lines. Simultaneously, the system processed the infrared images to detect hot spots in the power lines by estimating the threshold based on Otsu method and later segment the lines from the background [4]. More recently, Vega et al. presented a system based on a quadrotor helicopter for monitoring the power lines [5]. They estimated the relative temperature of the joints for qualitative inspection. The increase of the electrical resistivity at the joints is directly proportional to the temperature at the joint. Initially, the background of the thermal image was removed, and then the joints of the power lines, located in the foreground, were analyzed. They performed a thresholding-based segmentation to isolate these joints from background. On the other side, Lages et al captured video streams from both an infrared and visible cameras, simultaneously [6]. They used both statistical and morphological methods to highlight the hot spots in the lines. Their first step is to segment the image in lower and high temperature areas, by thresholding; later, the foreground is further processed looking for hot-spots. The background is discarded. Oliveira et al. discussed in detail the generation of hot spots in the transmission lines and later they had also used the same thresholding based segmentation to highlight hot spots [7]. Several of the above mentioned and similar methods require manual operations to adjust threshold values; hence there is a risk of a high measurement error because of the influence of the background, lack of reference temperature values, and changeable emissivity or reflection of radiation from other elements surrounding power lines. For this reason, recently Wronkowicz had proposed an automated method for the hot spot detection from IR images of power transmission lines, without any reference temperature value [8]. The threshold for image segmentation is selected automatically by finding the steepest growth of successive gradients of sorted values of input image, after certain image pre-processing steps.

Processing of RGB data

In recent years, tremendous efforts have been deveoted to the automation of power lines detection from aerial RGB images. Many methods, based on recent advances in aerial photogrammetry, have been proposed to detect and inspect power lines in real time. Oberweger et al. presented in [9] a method to detect the insulators in aerial images, and to automatically analyze them for possible faults. Their method is based on discriminative training of local gradient-based descriptors and a subsequent voting scheme for localization. More recently, Li et al. used the human attention mechanism model and the binocular vision system to detect and track power lines in image sequences according to their shape [10]. The binocular visual model is used to calculate the 3D coordinates of both obstacles and power lines. The proposed method uses a SURF-based matching strategy to improve the real time computation and accuracy of the system. The experimental results show that the inspection system is effective even in complex backgrounds and under different conditions. Zhang et al. transformed the RGB image to the gradient image, and extracted the power lines by the Otsu thresholding [11]. They performed K-means in the Hough space to cluster and filter the straight lines; and Kalman filtering to predict the position of power lines in the next frame, assuming the continuous nature of video frames. Similarly, Li et al. in [12] proposed a more complex filter based on a simplified pulse coupled neural network model. This filter can simultaneously remove the background noise as well as generate edge maps. An improved Hough transform, performing knowledge-based line clustering in the Hough space, detected the power transmission lines. Song and Li in [13] first generated a line segment pool by match filtering and first-order derivative of Gaussian. Later, a graph-cut model is used to group the lines corresponding to the power lines. This method can detect not only the straight power lines but also the curve ones. Candamo detected power transmission lines from low quality videos combining the motion estimation at the pixel level with the edge detection, followed by a windowed Hough transform [14]. Yan et al. extracted straight line segments by Radon transform, followed by a Kalman filtering to connect segments into whole lines [15]. More detailed summary of some more methods were given by Kartransnik and Miralla in [16, 17].

Conclusion

In this paper, we have studied different inspection methods based on visible and infrared images designed to detect and inspect power transmission lines. Infrared imaging applied to power lines monitoring account for the differences of temperature at the joints; hence it is used for the fault diagnosis. Most of the methods performed simple thresholding to separate foreground from the scene. On the other hand, image processing applied to RGB images and videos is able to provide quite an accurate localization of the inspected power lines, by applying standard computer vision techniques (e.g. denoising, filtering, segmentation, line detection). Using more advanced techniques (e.g. Kalman filtering, 3D photogrammetry, neural networks) it is possible to perform a detection and tracking of power lines in almost real time, during the autonomous inspection. The integration of the processing of both data (i.e., thermal infrared and visible) is a key point to have not only an accurate detection and tracking of the power lines, but also to have a reliable and robust assessment of the maintenance status of the whole infrastructure.

SCIADRO Project

This work is being carried out in the framework of the Tuscany regional project "SCIADRO" [18]. The project aims at developing the enabling technologies, which are key to accomplishing a rather rich and diverse span of missions through the use of a coordinated drone swarm within a civilian environment. In detail, the project aims at: (i) achieving computer vision techniques and algorithms able to detect complex objects and extract information on local anomalies which might affect them; (ii) developing suitable logics and algorithms to effectively organize and guide the overall swarm motion and actions during a mission; (iii) studying, developing and demonstrating network architectures and protocols allowing communication among multiple drones within a swarm, possibly increasing the communication reliability towards the ground segment.

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