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DETECTION OF HIGH VOLTAGE LINES BASED ON ANALYZING IMAGES RECEIVED FROM AN UAV IN ORDER TO DETECT CORONA DISCHARGE

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Abstract:*In the high voltage domain, the Corona discharge represents one of the most disturbing problems for the companies that transport electricity. Corona discharge is an electrical discharge brought on by the ionization of a fluid surrounding a conductor that is electrically energized. To combat this phenomenon it is necessary to keep high voltage power lines under surveillance and try to maintain losses at a reasonable value. The best manner to do this thing is by using a fixed-wing unmanned aircraft vehicle having on board the necessary sensors for detecting Corona discharge. In this paper we will focus on extracting and detecting high voltage lines from the images received from an UAV which will be analyzed using a number ofMATLAB functions. To detect lines into an image the Radon transformwill be used which is an integral transform that maps a function to its integrals over lines.*

Keywords: Corona discharge, UAV, high voltage power lines, image analysis, Radon transform.

1. Introduction

During the recent decades concerns over losses on high voltage power lines have increased significantly. The main problem facing engineers working on the biggest electricity transportation companies is fighting Corona discharge. Corona discharge is an autonomous process that occurs around an electrode with a small radius of curvature when a voltage equal to or greater than a minimum value is applied. This value depends on the geometrical characteristics of the electrode and the environment in which the discharge occurs. This occurrence of Corona discharge condition is represented by the existence of a sufficiently intense electric field at the electrode surface.The most harmful effects of corona discharge are radio interferences, active electrical power losses, aging of liquid or solid insulation and O_3 production. It is caused by some factors like voltage of the line, diameter of the conductor, the distance between conductors, local weather conditions, etc.[1].

For effective tracking and surveillance of high voltage power lines a UAV isneeded. Comparing fixed-wing UAVs and rotary-wing UAVs the best decision seems to be the fixed-wing one because it presents the major advantage that it can fly much longer distances even if the accuracy of the camera is lower. The electrical equipment placed on board of the aircraft is composed of: an optical camera, ArduPlane Mega (APM vs. 2.6), 6-channel 2.4 GHz Spektrum transmitter, Spektrum AR610 6-channel DSMX receiver.

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For image analysis a GCS is required which is able to support on it the following software:

Mission Planner and MATLAB. Most of the research described in this paper is executed in MATLAB analyzing each image sent by the aircraft to detect high voltage power lines in this image. The main purpose or this work is to create a Matlab command for an UAV to detect the high voltage lines from an image. This can be accomplished using Radon Transform whichis the integral transform consisting of the integral of a function over straight lines.

2. Radon transform

To be able to study different reconstruction techniques, we first need to write a (Matlab) program that creates projections of a known image. Having the original image along with the projections gives us some idea of how well our algorithm performs.The Radon transform is able to extract line parameters from a 2D image which contains lines.

Applying the Radon transform on an image$f(x,y)$ for a given set of angles can be thought of as computing the projection of the image along the given angles, where f is a compactly supported continuous function on $\mathbf{R}^2$.

The resulting projection is the sum of the intensities of the pixels in each direction (for example, a line integral). The result is a new image $R(\rho,\theta)$.

Therefore, the projection function $R(\rho,\theta)$ can be rewritten as (2.1):

$$R(\rho,\theta)=\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} f(x,y)\delta(\rho - x\cos\theta - y\sin\theta)dxdy \quad (2.1)$$

where δ is the Dirac function.[2]

The collection of these $R(\rho,\theta)$ at all θ is called the Radon Transform ofthe image $f(x,y)$.The Radon transform is a mapping from the Cartesian rectangular coordinates (x,y) to a distance and an angle (ρ,θ), also known as polar coordinates.

The Radon transform is the projection of the image intensity along a radial line oriented at a specificangle.If θ is a scalar, R is a column vector containing the Radon transform for θ degrees. If θ is a vector, R is a matrix in which each columnis the Radon transform for one of the angles in θ. If you omit θ in Matlab, it defaults to 0:179.The source and sensor vectorare rotated about the center of the object. For each angle θ the density of the material that the rays from the source pass through is accumulated at the sensor. This is repeated for a given set of angles, usually from $\theta\in$ [0;180). The angle 180 is not included since the result would be identical to the angle 0.

For each angle θ and each distance ρ the intensity of the material that a ray perpendicular to the ρ axis crosses are summed up at $R(\rho,\theta)$.

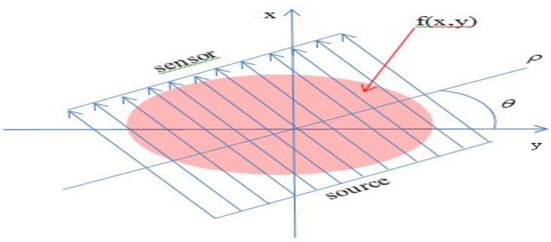

Fig.1 Radon transform

For a better explanation to understand how the Radon transform works with an image and how it detects a line from it,there are two graphics in fig.2 which show that every point will havea correspondent sine curvein the in Radon plane and if more points are collinear, then their sine curves intersect at one point which determines the line to whichit belongs[5].

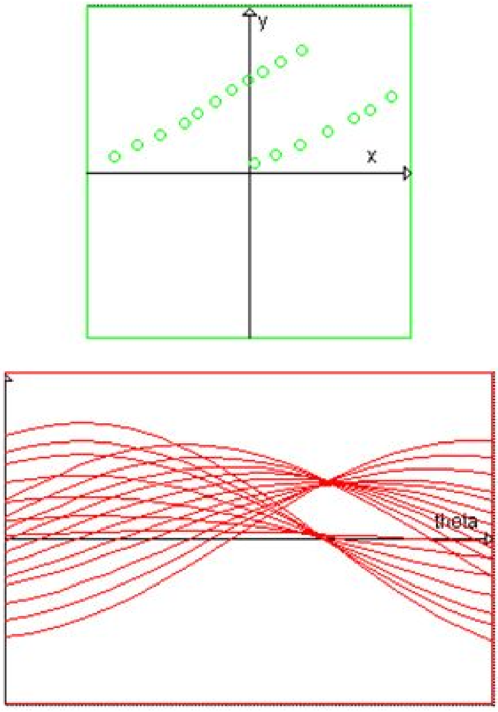

Fig.2.Line detection in Radon plane

3. Image analysis in MATLAB

The Radon transform can be implemented directly from Matlab as it is a predefined function but before the implementation of this transform we need to prepare the image using a number of techniques.

First, raw images that are received by the optical sensor on the aircraft are inserted in Matlab.

After that, it is necessary to convert this raw truecolor image to the grayscale intensity image (fig.3.a). The function **rgb2gray** converts RGB images to grayscale by eliminating the hue and saturation information while retaining the luminance.

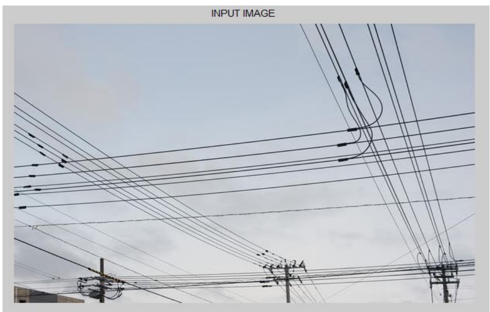

Fig.3. a) Input Image [7]

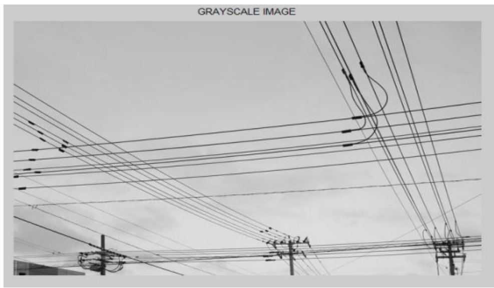

Fig.3. b) grayscale image

After that, the **edge** function is applied to the grayscale image obtained in the previous step. This is an image processing technique for finding the boundaries of objects within images.

After the **edge**function is applied to the grayscale image, the result is displayed in fig.4. [3]

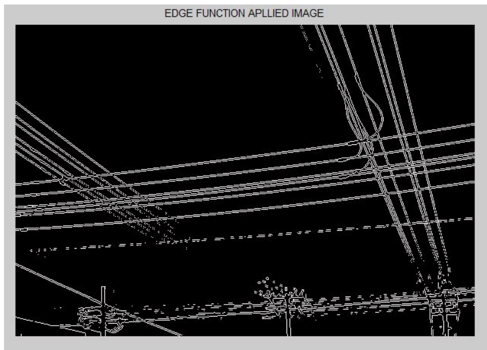

Fig.4. Edge function applied image

4. Detect a line from an image

The last step is the most important because until nowthe image was just prepared for the Radon transform function which is the main subject of discussion for this paper.

In fig. 5 the final image to which the Radon transform has been applied is displayed. As we can see there arestrong peaks in the Radon transform matrix. The locations of these peaks correspond to the location of straight lines in the original image (input image).[6]

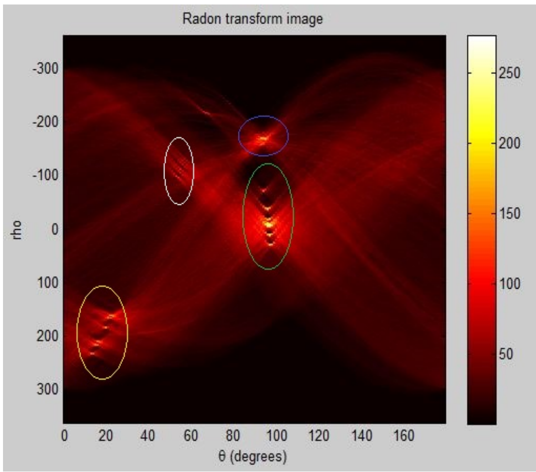

Fig.5. Radon transform applied image

5. Results

The green circle represents horizontal power lines which can be identifiedfor $\theta = 93^0$.

Aerial power lines which are localizedon the rightside of the image tend to be almost vertical and they can be identified for $\theta = 10^0 \div 20^0$. These linesare situatedinside the yellow circle.

The white circle surrounds the intensities of the pixels which represent the high voltage parallel oblique lines situated on the left side of the input image. For these lines the angle correspond $\theta = 50^0 \div 55^0$.

The bottom of the input image is represented with the blue circle.There is a very light peak whichrepresentsthe electrical power lines from the bottom of the image and it is lighter than other peaks because the electrical lines being so closeto each other are taken as a very thick one. For these lines we have also about $\theta = 90^0$, because they are almost horizontal.

6. Conclusions

As it is demonstrated before we can conclude that any line which tends to be horizontal into the image has θ very close to 90^0.

Also, for any vertical lines the value of θ will be equal to 0^0 or 180^0.

For an aircraft which wants to follow high electrical power lines after previously havinganalyzed an image, it is necessary to reduce as much as possible those lines which appear in the image and are not electrical lines as these are not interesting (roads, fences).

To achieve this it is important to apply a few constraints to be considered, like $\theta = 0^0 \div 15^0$ and $\theta = 165^0 \div 180^0$ because we suppose to keep the aircraft along the electrical power lines.

7. Future work

We will try to find a filter for the image to reduce the influence of the backgrounds and to emphasize only the electrical power lines.

Another thing that we want to do is the conversion ofMatlab code to C++ code using theMatlab compiler. The translated code can also be compiled into a stand-alone application that can run independently of Matlab, or can be integrated with any existing C++ application as a shared library.

It is also possible to call Matlab from C++ program using the Matlab Engine. After this code will be converted we can try to implement it on the APM 2.6. [4]

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