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VISUAL PARAMETER CALCULUS FOR GRIPPER TRANSLATION CORRECTION

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Abstract: Vision systems are used in a large scale in industrial applications. These systems work in real time in order to rapidly solve problems in flexible manufacturing systems. The paper presents some image processing strategies which are used to compute a robot gripper position in order to handle large objects as for example wooden pallets.

1. INTRODUCTION

In a previous work by the same authors, the main issues for a vision system were stated, which has the goal to calculate rotation of a robot gripper for a proper grip of a wooden pallet in a flexible packaging line. This has been achieved using the Hough transform. In this paper the second major problem is solved that is the translation or position correction of the gripper.

Several methods had been considered, as convolution in space domain, in frequency domain and some special designed methods adapted to solve this particular problem.

In order to pick up the pallets in a proper way the gripper has to be positioned at the middle of the pallet above the center of gravity. After solving the rotation of the gripper, the image of the pallet is represented in figure 1.a and 1.b.

The pallets are considered to be in a stack by 4 pieces one upon the other. The most probable case is that the pallets are not straight order one on the other but with some rotation and translation differences. There is also a possibility that the whole stack is not in the right place.

For a good grip of the robot arm on the pallet, piece by piece it is necessary to know the position of the center of gravity of the pallet in two coordinates x and y of a Cartesian coordinate system, which in image processing is assimilated with the index on lines and columns of the image and is translated further in coordinates after the image is calibrated.

So the aim of this work is to find a method to calculate the position of the center of gravity of a pallet from it's acquisitioned image after the rotation of the pallet had been found.

2. SPACE AND FREQUENCY DOMAIN CONVOLUTION CONSIDERATIONS

Linear image processing is based on the same two techniques as conventional DSP (Digital Signal Processing): convolution and Fourier analysis. Convolution is the more important of these two, since images have their information encoded in the spatial domain rather than the frequency domain. Linear filtering can improve images in many ways: sharpening the edges of objects, reducing random noise, correcting for unequal illumination, de-convolution to correct for blur and motion, etc. These procedures are carried out by convolving the original image with an appropriate filter kernel, producing the filtered image.

A serious problem with image convolution is the enormous number of calculations that need to be performed, often resulting in unacceptably long execution times. In some works on image processing, strategies for designing filter kernels for various image processing tasks are presented. Two important techniques for reducing the execution time are also described: convolution by separability and FFT (Fast Fourier Transform) convolution. Even though the Fourier transform is slow, it is still the fastest way to convolve an image with a large filter kernel. For example, convolving a 512×512 image with a 50×50 kernel is about 20 times faster using the FFT compared with conventional convolution. The two-dimensional version of FFT is a simple extension of the one dimensional FFT. Given an acquired image and a known pattern, the goal is to find out what is the most effective way to locate where the pattern appears in the image. The solution to this problem is correlation (a matched filter) and that it can be implemented by using convolution.

Before performing the actual convolution, there are some modifications that need to be made to turn the target image into a kernel. This is the rotation by 180º to undo the rotation inherent in convolution, allowing correlation to be performed.

3. IMAGE PROCESSING ALGORITHMS

In order to perform the pallet center computation, 3 methods had been tested.

At first we have selected two images with different pallet positions in order to be able to test the algorithms (figure 1.a and 1.b).

The first algorithm to be tested was the space domain convolution. For this method the kernel showed in figure 2.a had been generated and 2D convolution had been applied to the test images with this kernel.

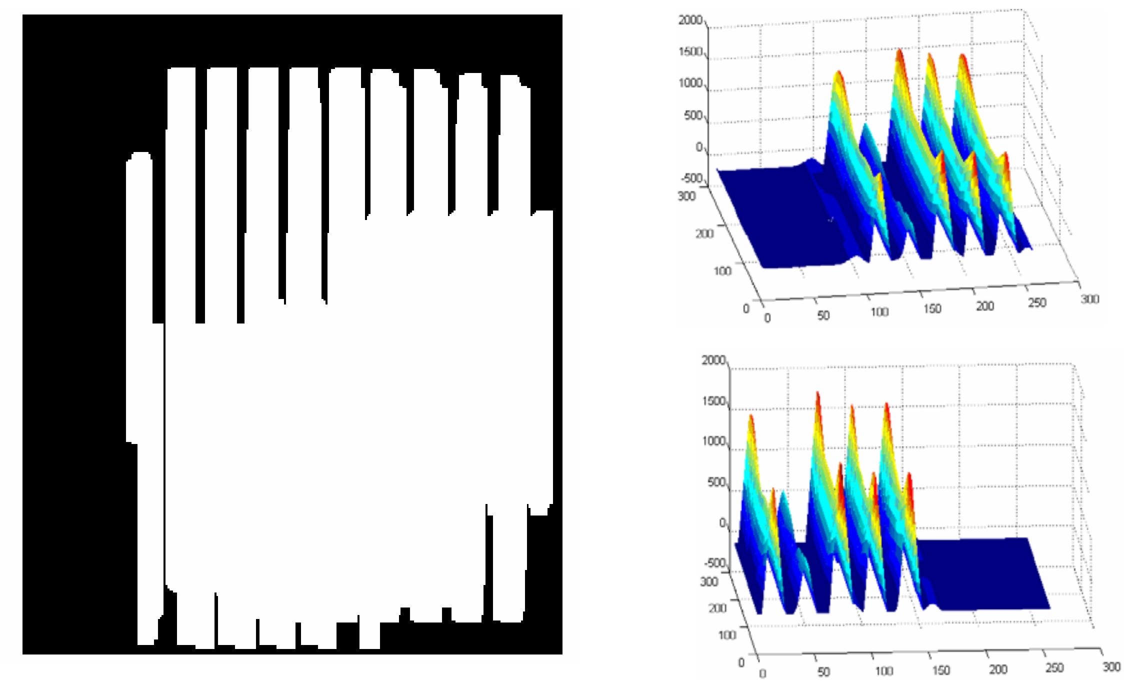
a. *b.*

Fig.1. Test images with different pallet position.

For this purpose the ‚conv2' MATLAB function was used. The convolution result for test image in figure 1.b, shown in figure 2.a. Is clear that this method can not produce good results because the white area in the resulted images covers a large space on which bases there is no chance to compute the coordinates of the center of pallet.

a. *b.*

Fig.2. Kernels used in space domain (a) and frequency domain (b) convolution.



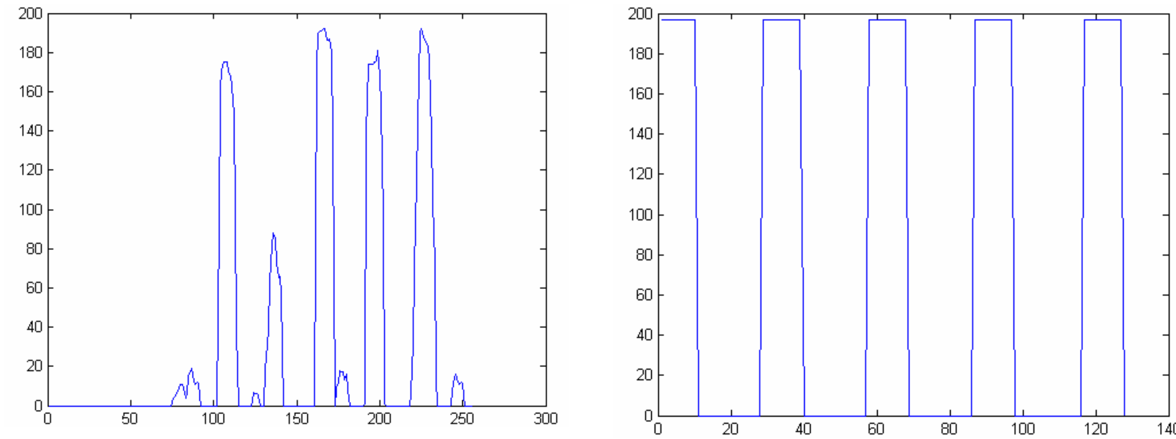
a. *b.*

Fig.3. Convolution result images for space domain (a) and frequency domain (b).

Frequency domain convolution is a little bit harder to achieve. At first we have to apply the 2D fast Fourier transform for the test image and also for the kernel (shown in figure 2.b). This kernel is the same with the one for space domain convolution only that is padded with zeros, to obtain the same size as the test image. After obtaining the transformed images the results are multiplied following the rules of complex matrix multiplication. a MATLAB program was developed to do the job. The results are presented in figure 3.b. for both test images. This result shows clearly that positioning of pallet image is correctly achieved on y direction (line wise), but it’s nearly impossible to compute on x direction (column wise).

So, we have to concluded that the presented methods are failing to achieve good results in pallet position calculation.

In order to solve the problem, we have adopted another approach, which seemed to be more simple. we tried to locate the center of the pallet separately on each direction. So computing the sum of pixels column-wise we can obtain the 1D graph presented in figure 4.a) and computing the sum of pixels in the same direction of the kernel the graph in figure 4.b. had been obtained.



a. b.

Fig.4. Summed projections on x direction of the test image (a), and the kernel (b).

We have computed then the convolution product of the two sums resulting the graph in figure 5. it can be observed that the graph is showing a clear maxima at point *x=166* (after the convolution half the length of kernel signal must be extracted both from the beginning and end of the graph).

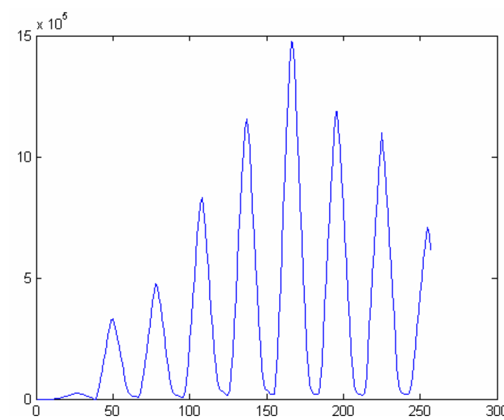


Fig.5. Convolution of vectors presented as graphs in figure 4.a and 4.b.

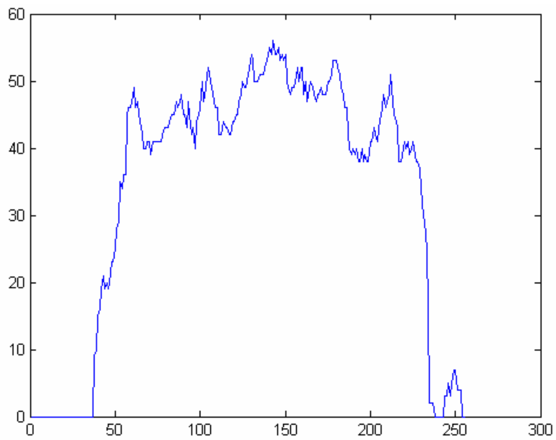
In order to find the center point of the graph line-wise we had computed also the sum of pixels on that direction, resulting the graph presented in figure 5.a. Appling a threshold of value 10 we can compute the vector of values that are higher than this, v_{rez}, with the following MATLAB expression:

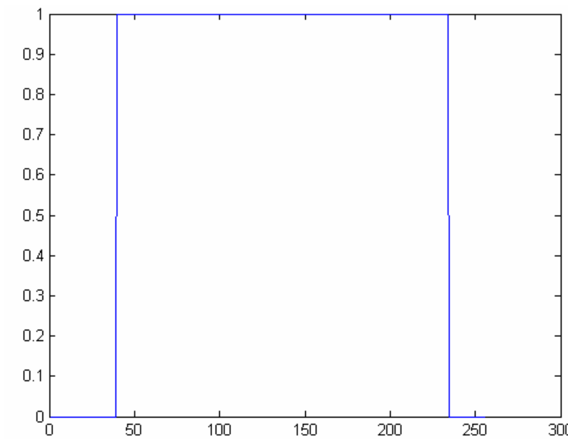
$$v_{rez} = find(sslin>10)$$

and find the value of the center of this region, which corresponds to the center of the pallet on this direction :

$$y_{cen} = v_{rez}(1) + (v_{rez}(length(v_{rez}))-vr_{ez}(1))/2$$

we find the coordinate *y = 137*.





a. ***b.***

Fig.6. Initial (a) and threshold (b) graphs of summed projection on y direction.

Marking the point *x=166* and *y=137*, on the test image, will yield the point presented in figure 7, which demonstrates that the computed point is indeed in the center of the pallet.

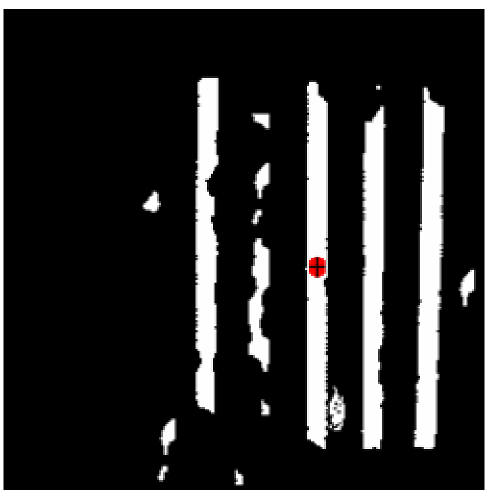


Fig.6. Computed center of pallet.

4. CONCLUSIONS

Comparing results obtained by applying the presented algorithms we can conclude that the space domain and frequency domain convolution are not suitable to fiind the center of the pallet in such images.

More adequate to solve this problem is the method of summed projection developed by the authors, which can find the center of the pallet with an accuracy fair enough to be used for robot gripper corrections.

For industrial use the algorithms found and tested in MATLAB language can be translated in other languages like C++ or Delphi.

REFERENCES

1. N. Otsu, "A Threshold Selection Method from Gray-Level Histograms," IEEE Transactions on Systems, Man, and Cybernetics, vol. 9, no. 1, pp. 62-66.
2. Parker, James R. Algorithms for Image Processing and Computer Vision. New York: John Wiley & Sons, Inc., 1997. pp. 23-29.
3. M. Nica, L. Grama, I. Mihaila, M. Ganea, G. Donca, D. Hirte. - SISTEM VIZUAL PENTRU DETERMINAREA PARAMETRILOR DE CORECŢIE A UNUI DISPOZITIV DE PREHENSIUNE, . Annals of the Oradea University, CD-ROM EDITION, 2006.