Optical information processing and the fusion of information spectrum

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Abstract :

The information fusion is the regrouping of the various techniques used to associate the information varied on the same problem[1][2][3]. In image processing, the information fusion is concerned with as well as possible combine images of different origins for better knowing the object of observation. Fusion became a significant aspect of information processing in several very different fields, in which information to be amalgamated, the objectives, the methods, and thus the terminology, can vary much, even if the analogies are also numerous. The width which the information fusion takes follows that which technologies and the information processing take in general. The method of fusion that we go presented in this article is based on a regrouping of information in the spectral field. This technique was applied in the framework of the multicorrelation[4], compression, the multiplexing encryption[5]. For these operations we chose a technique to amalgamate information in the spectral field.

I. Introduction

The correlation which is one of the significant operations in optical information processing was the subject of several studies to improve its computing time. This last can be penalizing if we deal with the multicorrelation. An algorithm being based on the segmentation of information in the spectral field was proposed in order to optimize this computing time. The aim of this algorithm is to gather relevant information of each reference belonging to the reference index in only one reference (filter of correlation) and of this fact we bring back the problem to a simple correlation in the spectral field. This gathering of this information must be made according to a well defined criterion of segmentation and consequently the energy criterion was retained. This criterion consists in calculating or measuring the relative information of the pixels of an image spectrum by comparing them with the pixels of one or other spectra. In this article we will make a critical study of the feasibility of the optical information processing by fusion of spectral information by linear and nonlinear combination. Our study will be to apply to a method of optical compression and multiplexing.

II. Information fusion : Application

II-1. Compression and multiplexing

The principle of the method of optical compression and multiplexing consists in amalgamating the spectra of the deferent images after the realization of their Fourier transformation separately, and associating each spectrum the carriers ones (terms of phase) in order to separate them in the output plane. In this application the information fusion consists in gathering information of the images to be compressed and multiplexed in only one plane then to transmit this last. That in order to avoid transmitting the images one by one what makes it possible by consequence to reduce the time of transmission[6].

II-1. Encryption

The method of encoding using a segmented mask consists in multiplying the image to be encrypted by a phase mask. This last is manufactured based on a fusion (segmentation) several keys. This regrouping is manufactured in the same way as the method of compression and multiplexing except that here we are interested in the phase rather than with the amplitude, i.e. than we place the phase of the pixel gaining in the segmentation plane [5].

III. Fusion of information using the energy criterion

The criterion that we chose is the energy criterion, it is defined as follows:

$$\frac{E_{ij}^{k}}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{k}} \leq \begin{cases} \dfrac{E_{ij}^{0}}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{0}} \\ \dfrac{E_{ij}^{1}}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{1}} \\ \vdots \\ \dfrac{E_{ij}^{L-2}}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{L-2}} \end{cases}$$

$l = 0,\dots, L-2$ avec $l \neq k$ Equation 1

where L is the number of references, N the size of the filter plane and $E_{ij}(k,l)$ is the spectral energy of the class "i " to the pixel (k,l). Physically, this criterion compares, for every pixel, the energy of a class given to the total energy of this class on the whole Fourier plane with the one of the other classes, it represents the relative importance of this pixel (i,j) within a k class. The decision to affect this pixel to a class or another, is taken on the set of these comparisons, while affecting this pixel to the class for which it presents the strongest relative importance.

Knowing that a pixel in the spectral field is represented in the form $\rho e^{j\phi}$ with ρ the amplitude and ϕ the phase. The phase is a significant component of an image spectrum and the criterion defined in equation 1 does not take into account this component of phase[7]. In order to take into account the phase we will compare the terms with $\left(\cos\phi_{ij}^{k}\right)^2$ with the place of the all alone amplitude, and thus we have information on the phase[8]. By adding the terms in consinus equation 1 gives:

$$\frac{\left(\rho_{ij}^{k}\cos\phi_{ij}^{k}\right)^2}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{k}} \leq \begin{cases} \dfrac{\left(\rho_{ij}^{0}\cos\phi_{ij}^{0}\right)^2}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{0}} \\ \dfrac{\left(\rho_{ij}^{1}\cos\phi_{ij}^{1}\right)^2}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{1}} \\ \vdots \\ \dfrac{\left(\rho_{ij}^{L-2}\cos\phi_{ij}^{L-2}\right)^2}{\sum_{i=0}^{N}\sum_{j=0}^{N} E_{ij}^{L-2}} \end{cases}$$

$l = 0,\dots, L-2$ avec $l \neq k$ Equation 2

In order to test the robustness and the effect of the phase on the segmentation we will compare it to the result obtained with that obtained by applying equation 1. As we have just described it, our approach by segmentation is based on the distribution of the spectral plane in several zones. Then assigns a zone to only one class. For that we chose base of images made up of four letters (two arab letters "alif" and "dad", and two latin letters "has" and "S"), then we carry out the segmentation with these letters, we display the false spectrum (we allot to the pixels gaining of the same image a color).

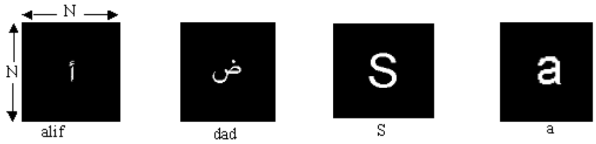

Figure 1 : base of images used

The false spectrum of these four images without considering the phase is presented on figure 2 (on the left).

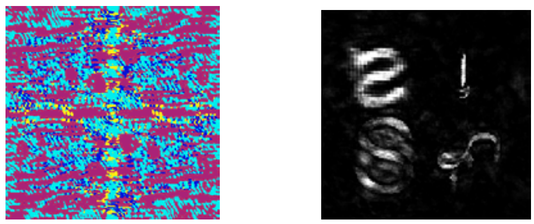

Figure 2 : In the left false spectrum of the letters "alif", "dad", "S" et "a". In the right the inverse Fourier transformation of the false spectrum without the phase

We notice on this figure the presence of four colors what means the taking into account of the spectra of all the images.
Now we go presented on figure 3 the false spectrum of the letters of figure 1 by considering the phase:

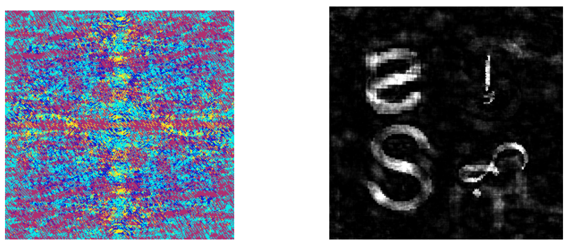

Figure 3 : In the left false spectrum of the letters "alif", "dad", "S" et "a". In the right the inverse Fourier transformation of the false spectrum with the phase

We notice on figure 3 the presence of four colors what means also the taking into account of the spectra of all the images.
By analyzing the two false spectra of figures 2 and 3 we can say that the information fusion without taking into account of the phase gives us more space i.e. that its band-width is larger compared to figure 3. This advantage enables us to amalgamate of advantage of the images, and especially to enable us to add the carrying ones in order to separate the various images in the output plane. The results of reconstruction of figures 2 and 3, enables us to notice that the addition of phase make possible to recognize of advantage the letters.

IV. Segmentation by linear combination of "alif", "dad", "S" and "has"

In order to test the robustness of our segmentation technique, we chose as technique of reference the linear fusion. In this paragraph we will amalgamate information by making the sum of the spectra of the four images of figure 1.

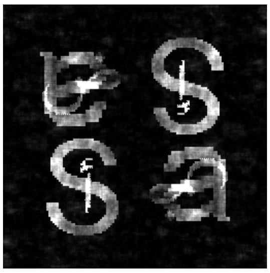

Figure 4 reconstruction with linear combination

We notice on figure 4 the overlapping of the letters what proves the limit of this method. The linear combination causes also the phenomenon of local saturation.
In the paragraph which follows we will try to analyze the energy criterion by making comparisons by regrouping of the pixels.

V. Segmentation by regrouping of the pixels of "dad" and "sad"

To test the good behavior of our segmentation technique, in this paragraph we will try to apply the energy criterion to two Arab letters which resemble each other, dad and sad which is differed by a point, in order to be able to test our method of information fusion. We will proceed by comparisons by regrouping of the pixels instead of comparing them one by one .

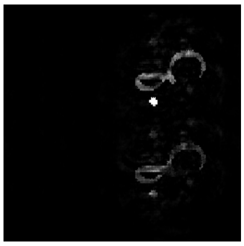

Figure 6 regrouping of 4 pixels

Figure 7 regrouping of 8 pixels

Figure 8 regrouping of 16 pixels

We displayed on the figures 6, 7 and 8 the result of the compression and the multiplexing of the letter dad and sad. We applied the energy criterion on region instead on one only of a pixel. The figure 6, for example, is the result of the application of the energy criterion on four pixels by four pixels. The figures 6, 7 and 8 show that the fact to apply the energy criterion on a region and not to only one pixel does not make improvement to the reconstruction. On the other hand it improves a letter in spite of the other. That led us to a thorough study of different the percentage from each spectrum.

VI. Calculation of the percentages :

In this paragraph we are going to try to improve the reconstruction while balancing the percentage of the pixels to the level of the application of the energizing criteria, every time we present a table of percentage and the reconstruction which is associated to him.

1)

Input images	**percentage**
I1	32,75
I2	52,88
I3	9,94
I4	4,41

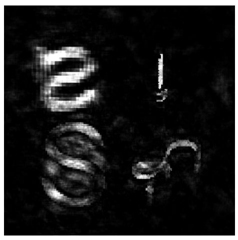

Figure 9 (without modification of percentage)

2)

Input images	percentage
I1	26,01
I2	37,43
I3	17,56
I4	18,97

Figure 10

3)

Input images	perrcentage
I1	26,05
I2	24,86
I3	26,04
I4	23,02

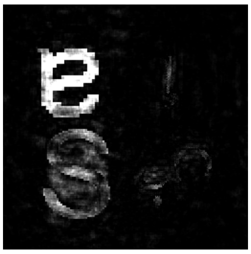

Figure 11

4)

Input images	perrcentage
I1	24,13
I2	25,64
I3	24,24
I4	25,97

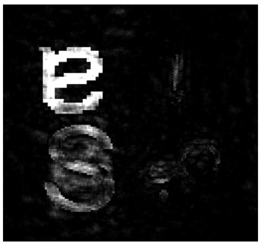

Figure 12

According to figure 10,11 and 12 we notice that even if by making a balance of the percentage of the pixels on the level of the application of the energy criterion, the reconstruction does not improve. With balance, we notice on figure 12 there is improvement of the letter a, one manages to recognize the letter S but we don't recognize the letter alif and dad.

VII. Conclusion

We have tryed to present in this article a method of information fusion in the spectral field, we did that by using the energy criterion. This criterion showed its adaptation in our research to knowing the optical information processing and more precisely compression, multiplexing and encryption. In this article we gave a critical approach of this criterion by validating each approach by the simulations applied to the method of compression and multiplexing.

VIII. References

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