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FACE RECOGNITION PERFORMANCES WITH PHASE INPUT JOINT TRANSFORM CORRELATORS[1]

Alin C. TEUŞDEA

University of Oradea, Environmental Faculty

B-dul Gen Magheru 26, Oradea 410048, BH, E-mail: ateusdea@yahoo.co.uk

Abstract

Former works prove that phase input joint transform correlators have better detection efficiency than the amplitude ones. The preprocessed phase input joint transform correlator has the best detection efficiency. This correlator needs as parameters: the amplitude premodulation domain, $dfPRE$, and the phase modulation domain, $dfPSLM$.

Face recognition implies that the real world scene images are embedded in noise threfore it is important to test the correlators in these conditions. Computer simulations were done on some combinations of amplitude premodulation domains and phase modulation domains for four input images. Two images have black (null) background and grey (average) background and two images have two kinds of embedding noise. These simulations were done to find the combination of the amplitude premodulation domain and phase modulation domain that has the best detection efficiency for all images.

Keywords: pattern recognition, phase joint transform correlators.

1. Introduction

Continuous surface objects, like human faces, are recognized without difficulties with joint transform correlators or modified models. The embedding and additive noises give more noncontinuous definition to surfaces and make it almost impossible to discriminate between the target image and the reference one from scene image. There are many modified joint transform correlators: modified amplitude joint transform correlator (MAJTC) [1-3], modified phase input joint transform correlator (MPJTC) [4-7] and preprocessed modified joint transform correlator (preMPJTC) [8, 9] that can detect objects with additive or embedding noises.

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In this paper the performances of previously mentioned joint transform correlators are compared to embedding noise and different background levels. Nonzero background gives better detection efficiency in optical correlation. Using such a background level might give a solution to alleviate the embedding or additive noises effects in optical pattern recognition.

2. Theoretical analysis

2.1 Classical phase transformation

This method assumes that the intensity image $IntensityOB(x,y)$ is somehow transformed from intensity grey levels (usually from 0 to 255) in phase levels (usually $dfPSLM \equiv \pi - 0$, but nowadays there are also $dfPSLM \equiv 2\pi - 0$), using a transformation function $Tf[\cdot]$, obtaining a phase image $PhaseOB(x,y)$ [2, 4] that mathematically is described by:

$$\begin{aligned} PhaseOB(x,y) &= \exp\left[i \cdot Tf\left[IntensityOB(x,y)\right]\right] \\ &= \exp\left[i \cdot \left(\frac{IntensityOB(x,y) - Min}{Max - Min}\right) \cdot dfPSLM\right], \end{aligned} \tag{1}$$

where $dfPSLM$ is the phase depth, Max, Min are the maximum and the minimum values of the intensity object. The modified phase input joint transform correlator (MPJTC) is the correlator that provides this kind of correlation process.

2.2 Modified input and phase transformation

The phase input joint transform correlator is reported to be noise sensitive. The combined joint transform correlator alleviates this problem but in certain conditions better pattern discriminability and better light diffraction efficiency is needed. The light diffraction efficiency can be improved if the dc term (which is the zero order diffraction term) of the power spectrum will drop and the high spatial frequencies will increase. The high spatial frequencies are connected to the object details in spatial coordinates. If the power spectrum will have a thin dc term and large high spatial frequencies, the correlation process will provide a better pattern discrimination because the objects will be “compared” more in their details. To achieve this goal the author suggests an alternate transformation which consists off applying an amplitude preprocessing function. The amplitude preprocessing function is the sine function, which stretches the dc term and enlarges the high spatial frequencies

$$\begin{aligned} PhaseOB(x,y) &= \left[Tf\left[\sin\left(IntensityOB(x,y)\right)\right]\right] \\ &= \exp\left\{i \cdot \left[\sin\left(\frac{IntensityOB(x,y) - Min}{Max - Min} \cdot dfPRE + fPRE_1\right) \cdot dfPSLM\right]\right\}. \end{aligned} \tag{2}$$

where $dfPRE = fPRE_2 - fPRE_1$ is the amplitude premodulation domain [8, 9].

One reason why the preprocessing function stretches the dc term and enlarges the high spatial frequencies is that it automatically adjusts the background level in order to have best detection efficiency. This preprocessing function has an amplitude premodulation domain, $dfPRE = fPRE2 - fPRE1$, that is in fact an extra freedom degree. The amplitude premodulation domain can be used to adjust the background levels to achieve different pattern discriminability. The preprocessed modified phase input joint transform correlator (preMPJTC) is the correlator that provides this kind of correlation process.

3. Results and Discussions

Simulations were done with joint input images with two background levels, fig. 1 and fig. 2, and one embedding environment, fig. 3 and fig 4. The phase modulation domain for both phase input joint transform correlators is set at $dfPSLM = \pi - 0$. The amplitude premodulation domain for the preprocessed modified phase input joint transform correlator is set in the first case at $dfPRE = [-\pi/2; \pi/2]$ and in the second case at $dfPRE = [0; 2\pi]$.

Fig. 1 Input image with black (null) background and small embedding noise (image code **2N512**)

Fig. 2 Input image with grey (average) background and small embedding noise (image code **2N512f**)

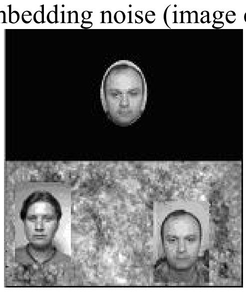

Fig. 3 Input image with black (null) background and large embedding noise (image code **2N512z**)

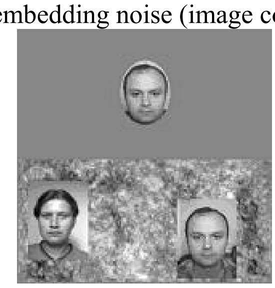

Fig. 4 Input image with grey (average) background and large embedding noise (image code **2N512fz**)

The correlations results in the output plane for the three joint transform correlators are presented in fig. 5. These numerical results were obtained by introducing the detection efficiency coefficient $SCR = API/CPI$, where API is the autocorrelation peak intensity and CPI is the highest value cross-correlation peak intensity. The embedding noise has a poor effect on detection efficiency (SCR coefficient) for all three modified joint transform correlators, thus these correlators are very robust to any embedding noise. The nonzero background level performs a better detection efficiency (higher SCR coefficient) with or without the embedding noise for all three modified joint transform correlators. The preprocessed modified joint transform correlator has different behaviours in relation with the amplitude premodulation domains. In the first case it has the same behaviour as the other two correlators with a small increase of detection efficiency (SCR coefficient). In the second case the detection efficiency is very high and is independent of the background level.

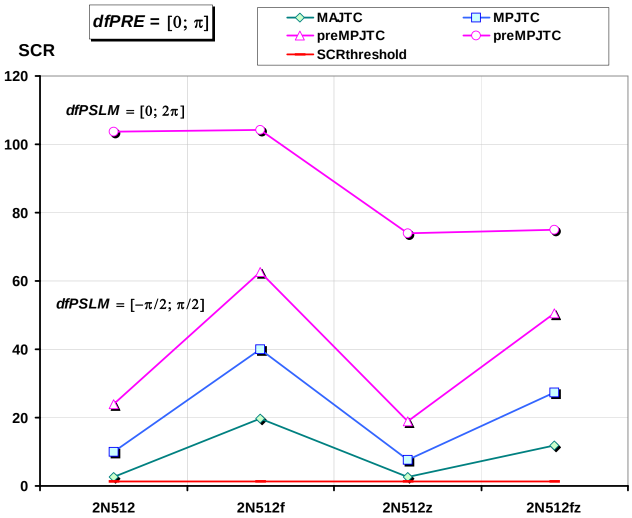

Fig. 5 Output correlation results for each studied joint transform correlators

4. Conclusions

The modified phase input joint transform correlator (preMPJTC) has the best detection efficiency with or without embedding noise. One reason for this performance is that preprocessing function automatically adjusts the background level, no matter if it is a nonzero level or not. Future work can involve the additive noise effect instead of embedding noise in the same fashion as in this paper.

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