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NOISE ROBUSTNESS FACE RECOGNITION WITH PHASE INPUT JOINT TRANSFORM CORRELATORS

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Abstract
Face recognition implies that the real world scene images are embedded in noise and mix with additive noise therefore it is important to test the correlators in these conditions. Simulations were done on some combinations of amplitude premodulation domains and phase modulation for four input images. Two images have black (null) background and grey (average) background and two images have two kinds of embedding noise. The reference type image from scene image has 50% additive noise for all four test images. 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 input joint transform correlators, additive noise.

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.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:

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

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

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

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 which have two background levels, fig. 1 and fig. 2, and one embedding environment, fig. 3 and fig 4. In all four input images the reference type image has a 50% random additive noise. 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 $dfPRE = [0; 2\pi]$.

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.

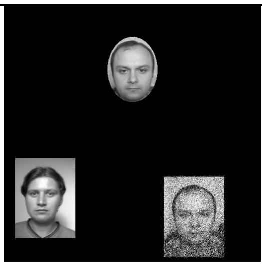

Fig. 1 *Input image with black (null) background and small embedding noise (image code* ***2N51250r****).*

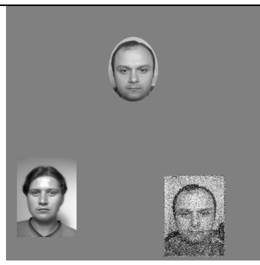

Fig. 2 *Input image with grey (average) background and small embedding noise (image code* ***2N51250rf****).*

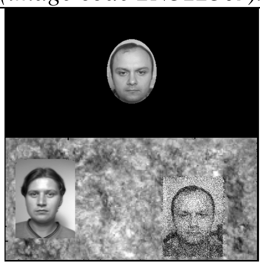

Fig. 3 *Input image with black (null) background and large embedding noise (image code* ***2N51250rz****).*

Fig. 4 *Input image with grey (average) background and large embedding noise (image code* ***2N51250rfz****).*

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 the embedding and additive noise for all three modified joint transform correlators.

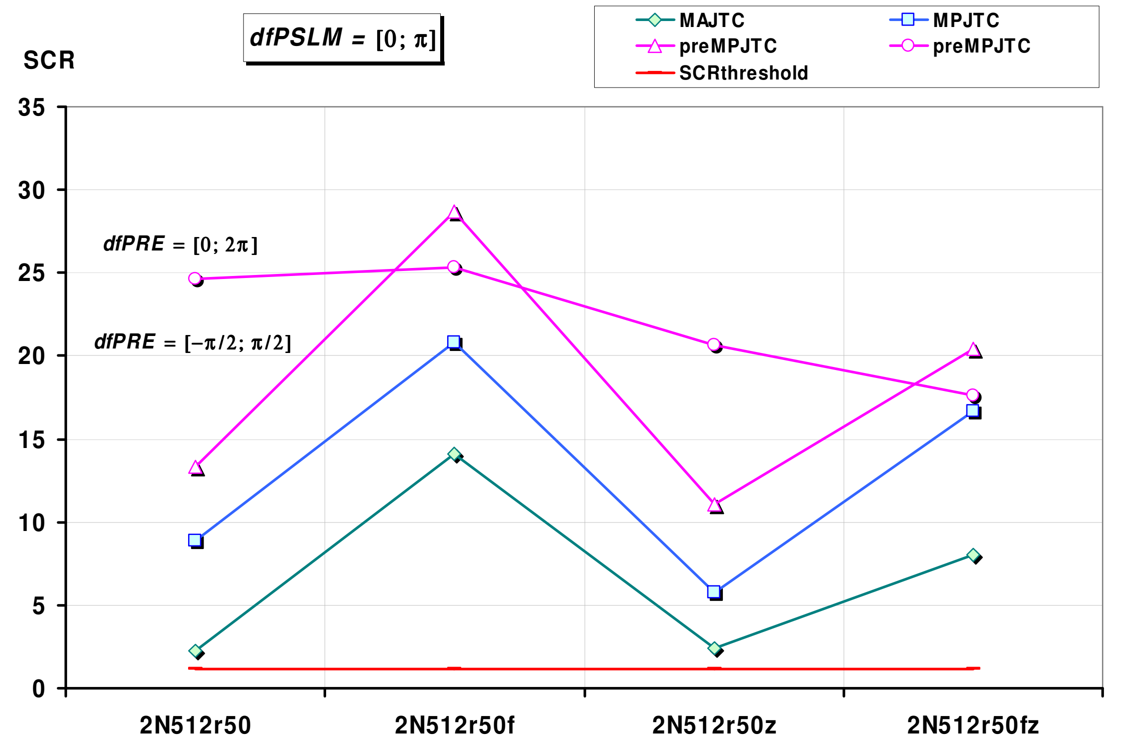

Fig. 5 *Output correlation results for each studied joint transform correlators.*

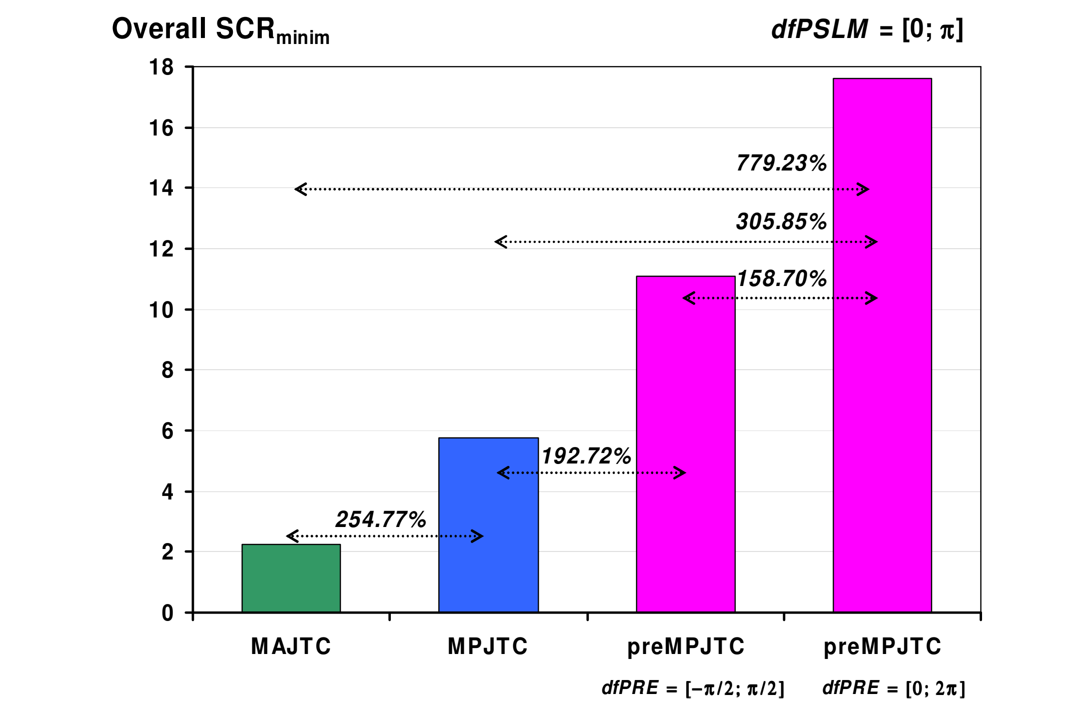

Fig. 6 *Correlation results comparison for studied joint transform correlators.*

The preprocessed modified joint transform correlator has different behaviours in relation with the amplitude premodulation domains. In the first case, $dfPRE = [-\pi/2; \pi/2]$, it has the same behaviour as the other two correlators with a increase of detection efficiency (SCR coefficient). In the second case, $dfPRE = [0; 2\pi]$, the detection efficiency is relative high only for nonzero background images and is smaller in the null background level images.

4. Conclusions

The modified phase input joint transform correlator (preMPJTC) has the best detection efficiencies with or without embedding noise and with 50% random additive noise in the reference type image. One reason for this performance is that preprocessing function automatically adjusts the background level, no matter if it is a nonzero level. Previous work [10] has the same approach, with the same input images but without additive noise. Those results had greater SCR coefficients than in this work. In conclusion the additive noise represents a higher perturbation than the embedding noise for these joint transform correlators.

References

[1] F.T.S.Yu, Guowen Lu, Mingzhe Lu and Dazun Zao, Appl. Opt. 34, 1386-1387 (1995).

[2] RuiKang K. Wang, Ling Shang, Chris R. Chatwin, Appl. Opt. 35, 286-295 (1996).

[3] Guowen Lu, F.T.S. Yu, Appl. Opt. 35, 304-313 (1996).

[4] Howard E. Michel, Abdul Ahad S. Awwal, Opt. Engineering 37(01), 33-37 (1998).

[5] Dennis M. Silva, Ikram E. Abdou, Russell E. Warren, Opt. Engineering 37(01), 83-92 (1998).

[6] Y. Li and J. Rosen, Appl. Opt. 39, 1251-1259 (2000).

[7] Y. Li, K. Kreske and J. Rosen, Appl. Opt. 39, 5295-5301 (2000).

[8] A. C. Teuşdea, Proceedings of 27th Annual Congress of the American-Romanian Academy of Arts and Sciences, Polytechnic International Press, Montreal, Canada, Physics and Chemistry Section, Vol. II, 1399-1403, (2002).

[9] A. C. Teuşdea, Proceedings of 29th Annual Congress of the American-Romanian Academy of Arts and Sciences, Alma Mater Publishing House, 505-509, (2004).

[10] Alin C. Teuşdea, Analele Universității din Timişoara, Vol. 46, 63-67, (2006).