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Letters to the Editor

Recognition of complementary signals

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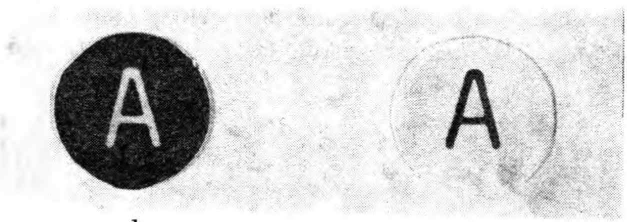
1. Introduction

The pattern of recognition consists essentially in a comparison of the unknown signal with a reference pattern. The comparison can be performed in Fourier plane of imaging system (van der Lugt correlator) [1] or – in the case of diffuse illumination – in Fresnel zone diffraction (quasi-Fourier correlator) [2]. The identity of the signals compared is indicated by the autocorrelation function that appears in the imaging plane of the recognizing system [3–5].

The question arises, how the compared complementary signals are seen in optical correlator system.

2. Complementary signals

Two signals are called complementary when one signal is a negative image of the second one. A simple example of a pair of complementary signals is shown in Fig. 1.



b a

Fig. 1. Complementary signals: negative (a), and positive (b)

The transmission t_N of the negative signal is

$$t_N(\vec{x}_0) = 1 - t_p(\vec{x}_0) \tag{1}$$

where $t_p(\vec{x}_0)$ is the transmission of the positive signal. Both signals are real and positive valued ones.

3. Correlation of complementary signals

Let us compare two pairs of signals: p_N, p_0, s_N, s_0. Negative and positive signals p and s are defined by the indices N and 0, respectively. Setting the signals in the input of optical correlator, and using one of them as a master signal which has formed the recognizing filter, we obtain correlation images in the image plane (correlation plane) of the system.

Let p_0 be the master signal. The correlation functions are:

$$p_0 * p_0,\; p_0 * p_N,\; p_0 * s_0,\; p_0 * s_N$$

($*$ is correlation symbol). The correlation is defined as follows:

$$p * p = \int p(\vec{x}_i - \vec{a})\, p^*(-\vec{x}_i)\, d\vec{a}.$$

Correlation images of $p_0 \otimes p_0$ and $p_0 \otimes s_0$ are well known autocorrelation and correlation functions. The first one is distinguished by the highest intensity maximum in the centre of the function (of the correlation image). How will the correlation images between $p_0 \otimes p_N$ and $p_0 \otimes s_N$ look like? Using Eq. (1) the autocorrelation of complementary signals can be set as follows:

$$p_0 * p_N = p_0 * (1 - p_0) = p_0 - p_0 * p_0. \tag{2}$$

In the correlation plane we obtain an image with the deepest intensity minimum in the centre. In the case of cross-correlation we get

$$p_0 * s_N = p_0 - p_0 * s_N. \tag{3}$$

Here the image intensity diminishes diffusely.

We see that autocorrelation of two signals is manifested in the intensity extremum — the maximum being in the case of the same signals, and the minimum in the case of complementary (negative and positive) signals.

Correlation images of simple negative and positive characters, obtained in quasi-coherent correlator, are shown in Fig. 2.

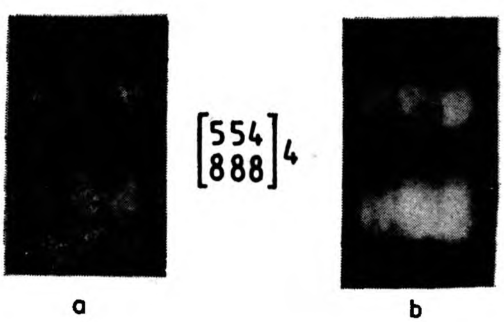


Fig. 2. Correlation images of signals both negative (a) and complementary (b)

Comparison of complementary (negative and positive) signals can be useful when printed characters are to be processed [6]. Sometimes it is easier to record the recognizing filter from the positive signals to compare them with negative signals introduced into the correlation system.

References

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