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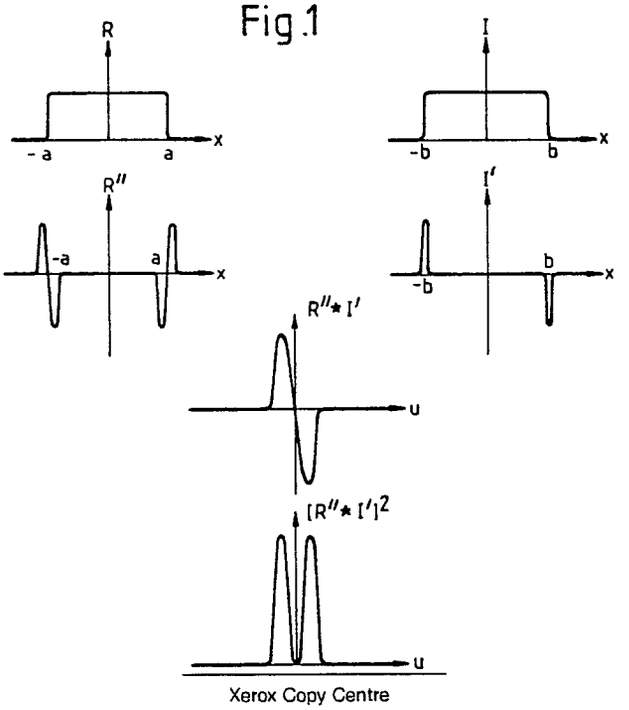
(54) Optical correlation.

(57) An optical correlation process involving correlating a second order differentiated reference function with a first order differentiated input function, or vice versa, so that the discriminating feature of a desired correlation is not only its intensity but also its characteristic form.

Fig.1



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OPTICAL CORRELATION

The present invention relates to an optical correlation process and to an optical correlator for carrying out such a process.

The invention relates to an optical correlation process in which an input function is derived from optical information from a field of view and a reference function is derived from a reference image e.g. stored in a matched spatial filter.

Optical correlation processing and edge enhancement (first and second order differentiation) and apparatus for carrying out these techniques are well documented and are familiar to the person skilled in the art and will not be described in detail here.

In conventional correlation systems, say where the reference and input functions are both differentiated twice, an autocorrelation function consists of a single intense peak with various side lobes. If scale mismatch is introduced the correlation maximum falls. In such a system the main discriminating feature between a 'target' cross-correlation and a 'clutter' cross-correlation is the maximum value of the correlation peak. Consequently high electronic threshold levels have to be set in the electronic imaging detector to suppress clutter, sometimes at the expense of target detection.

An object of the present invention is to provide an optical correlation process which is highly discriminating against clutter and which is sensitive to scale.

According to the present invention we provide an optical correlation process in which an input function is derived from optical information from a field of view and a reference function is derived from a reference image comprising:-

forming an m^{th} order differentiated input function;

forming an n^{th} order differentiated reference function;

where $m \neq n$,

and correlating said differentiated input and reference functions.

Preferably $|m-n| = 1$

A process according to the present invention will now be described, by way of example, with reference to the accompanying drawings in which:-

Figure 1 illustrates schematically the main stages of a process according to the present invention;

Figure 2 illustrates schematically how the cross- correlation central region varies as the scale of the reference and input functions vary in relation to one another.

Referring to Figure 1:

R = reference function amplitude;

R'' = second differential of R, i.e. $d^2R/_{dx}2$;

I = input function amplitude;

I' = first differential of I, i.e. $dI/_{dx}$; and * represents correlation.

The zero crossings of R'' occur at $x = \pm a$, and the maximum and minimum of I' occur at $x = -b$ and b respectively. If a and b are equal, correlating R'' with I' gives the function shown (plus low amplitude side lobes, not shown). $|R'' * I'|^2$ represents the observed energy or intensity in the correlation plane. The function's central region consists of two peaks either side of a minimum. If a is close to but not equal to b, the 'modulation depth' of this function is reduced (i.e. its value decreases at the maxima) and the distance between the peaks increases.

Figure 2 demonstrates how the cross-correlation central region varies as b increases or decreases to a.

In two dimensions the central region of an auto- correlation will consist of a single intense contour surrounding a zero. Again the modulation depth falls and the circumference of the contour increases, as the variation in scale between reference and input functions increase. Cross-correlation corresponding to clutter will be complex, noisy functions in comparison.

In the process described, the discriminating feature of a desired correlation is not only its intensity, but also its characteristic form. Relatively low electronic thresholds result in closed 'ring' like functions corresponding to targets. Simple, fast digital processing can readily distinguish these 'closed' shapes from other functions, thus providing high signal to clutter performance despite clutter cross-correlations being above threshold. The size of these 'ring functions' will give a very accurate indication of target scale/range; see Figure 2.

The main advantages of the process of the invention over conventional correlation processing are its ability to sense accurately the size/range of objects of interest, and to achieve good discrimination in cluttered environments.

It is envisaged that, as an alternative, to the embodiment described above, a first order differentiated reference function may be correlated with a second order differentiated input function.

Utilising higher order, differentiated input and reference functions may also be a possibility although more side lobes would be generated were suitable techniques available.

Claims

1. An optical correlation process in which an input function is derived from optical information from a field of view and a reference function is derived from a reference image comprising:-

forming an m^{th} order differentiated input function;

forming an n^{th} order differentiated reference function;

where $m \neq n$,

and correlating said differentiated input and reference functions.

2. A process according to Claim 1 wherein $|m-n| = 1$.

3. A process according to Claim 2 wherein $m = 1$ and $n = 2$.

4. A process according to Claim 2 wherein $m = 2$ and $n = 1$.

5. A process substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

6. An optical correlator adapted to carry out a correlation process as defined in any preceding claim.

Fig.1

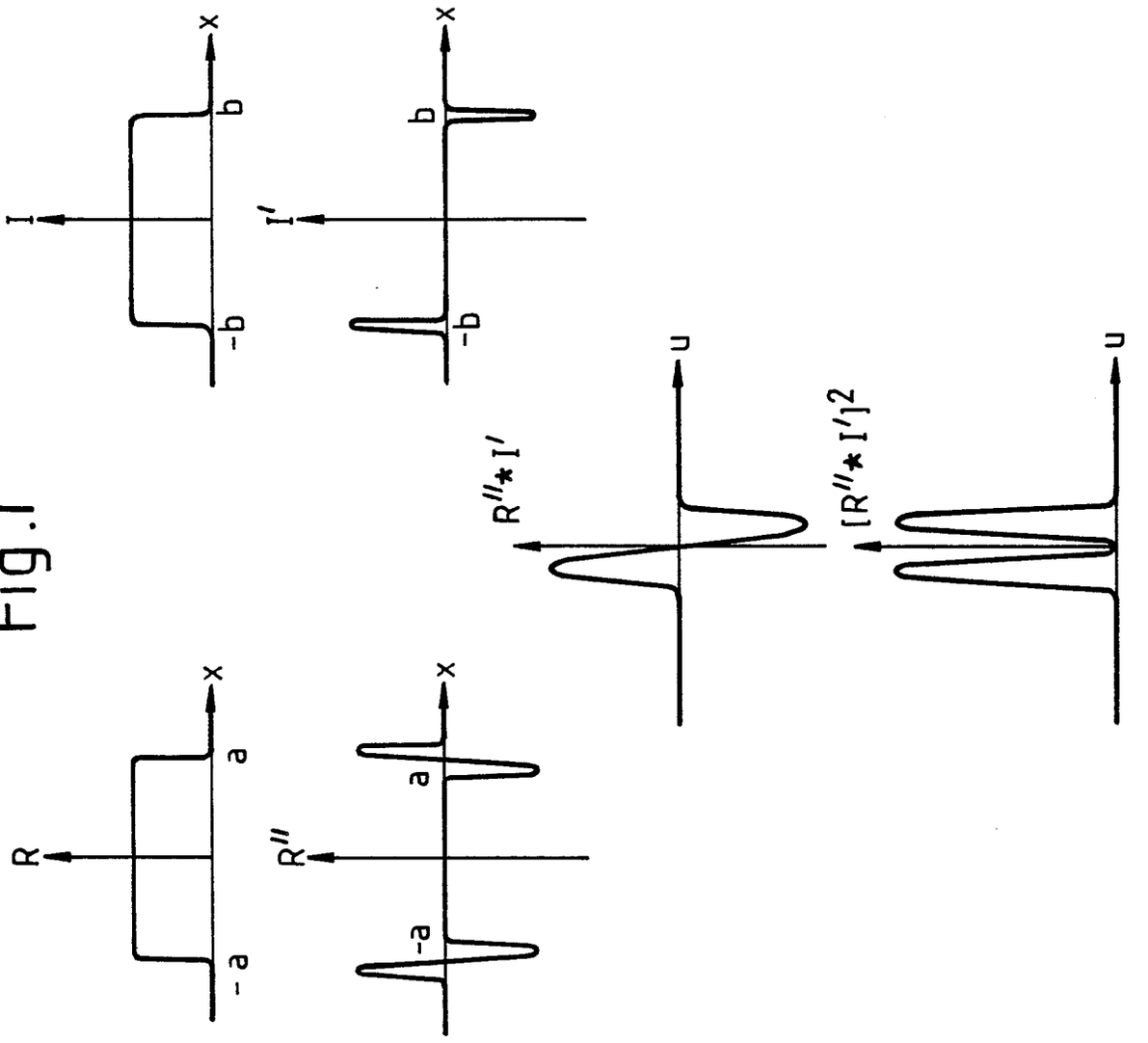

Fig. 2