A NEW MODIFICATION OF PHOTOMETRIC METHOD

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Abstract

For the digital 1D-image processing we go out from the so-called photometric method. For the concrete applications of the introduced method its accuracy lowers, owing to that the form of an output video signal of linear CCD sensor is not smooth and not symmetrical. In some cases the output video signal of linear CCD sensor is devalued by the certain disperse of pixel sensitivity, respectively also that a measured object and its background are not uniform. Therefore we introduce a new modification of photometric method. The obtained results show, that introduced method gives a possibility to raise the measurement accuracy of the object dimension considerably.

Keywords:

Linear CCD sensor, digital 1D-image processing, photometric method, edge detection, measurement of the object dimension

1. Subpixel photometric method for measurement of the object dimension

The linear CCD sensors with 256, 1024 or 2048 pixels are used, in the large measure, for measurement of the object dimension. This sort of measurement is based on evaluation of the edge position in the output video signal of CCD sensor [1]. We obtain two transitions in the video signal (WHITE-BLACK and BLACK-WHITE) by scanning one line of the measured black object on the white background. The higher definition of the edge position can be obtained by using various methods of digital processing of the video signal. One of those methods is the so-called SUBPIXEL PHOTOMETRIC METHOD [2]. This method goes out from the principle of equality area A_L and A_R, likewise how the simple photometric method [1], but in addition to it takes into consideration the width M of one pixel of CCD sensor Fig.1. In order that the edge position to be defined by value z_K, must hold the equality of area A_L and A_R. Therefore we have the following equation

$$\int_a^{z_K} y(x)dx = \int_{z_K}^{b} [F_m - y(x)]dx . \quad (1)$$

For the calculation of the edge position by this method is supposed, that the real edge is just situated in m-th pixel and the distribution function $y(x)$ for x from a to b is described by n pixels, with the width M of every pixel.

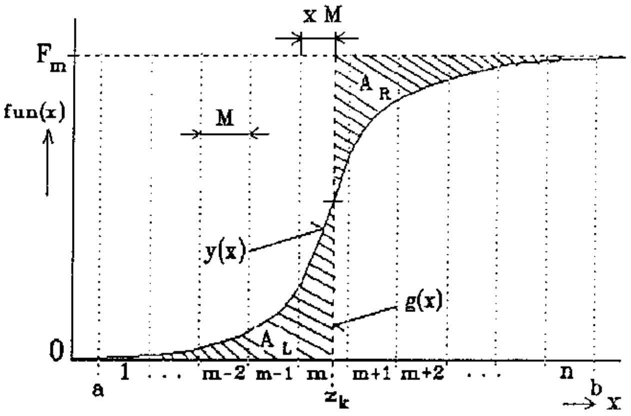

Fig.1
Place of edge position at m-th pixel of the CCD sensor

The edge position of the measured object in m-th pixel of CCD sensor we obtain, by this method, by the edge distance $x.M$ from the left margin of the m-th pixel according to equation

$$x.M = M(n - m + 1 - F) , F = \frac{\sum_{i=1}^{n} F_i}{F_m} , \quad (2)$$

where

- n - number of those pixels, which represent the transition BLACK-WHITE,
- m - order number of that pixel, in which the real edge is just situated (m is defined only in the interval <a,b>),
- F_i - discrete value of the signal level for i-th pixel of CCD sensor,
- F_m - value of the signal level, which corresponds to the most light pixel of CCD sensor;
- M - width of one pixel of CCD sensor,

- $x.M$ - edge distance from the left margin of m-th pixel of CCD sensor.

The equation (2) is already arranged to the suitable form for computer calculation. Simplifying the equation (2) yields

$$x = n - m + 1 - F\ . \tag{3}$$

Generally x satisfies the following inequality $0 \le x \le 1$. From this inequality and by the using equation (2), we can determine the order number m of that pixel, in which the real edge is just situated.

$$\text{If: } x = 0\ ,\ m = m_0\ ,\ m_0 = n + 1 - F, \tag{4}$$

$$\text{If: } x = 1\ ,\ m = m_1\ ,\ m_1 = n - F. \tag{5}$$

It is clear, from the equations (4) and (5), that the value m_0 is by 1 large than m_1, therefore we can choose one value from the interval (m_1, m_0) as the whole number m^*. For this value must hold the following inequality $m_1 < m^* < m_0$. From this value m^* is given a value x^* according to equation (3)

$$x^* = n - m^* + 1 - F\ . \tag{6}$$

This value x^* satisfies inequality $0 < x^* < 1$. By the introduced method we have precisely determined the edge position in the transition BLACK-WHITE, by order number m^* of that pixel, in which the real edge is just situated. The edge distance from the left margin of this pixel is $x^*.M$ (further $m^* = m$, $x^* = x$).

2. The modification of photometric method

For the concrete applications the accuracy of the above-mentioned method lowers, owing to that the form of output video signal of CCD sensor is not smooth and not symmetrical, as shown in Fig.2. In some cases the output video signal of CCD sensor is devalued by the considerable disperse of pixel sensitivity, respectively also that the measured object and its background are not uniform.

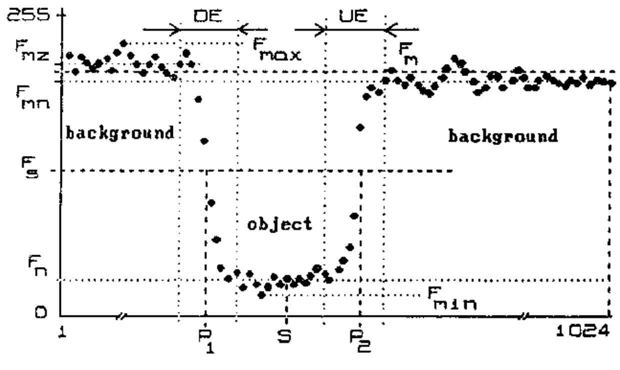

Fig.2
Digital representation of the video signal (DE-downward edge, UE-upward edge)

Therefore we introduce a new modification of photometric method.

Further, we assume that the signal, which corresponds to the measured object, was obtained by scanning camera with the 1024 pixel linear CCD sensor. The digital representation, for so obtained signal is shown in Fig.2. The minimum level of the video signal on Fig.2 is not zero. Therefore we divide this signal into some segments. These segments correspond to the measured black object, with two edges (*DE*, *UE*) and the white background. On this segmentation we obtain the maximum middle level F_m, for the white background and the minimum middle level F_n, for the measured black object. Now we shift the whole video signal by the value F_n into zero minimum level. Each of edge *DE* and *UE* we determine only by the certain number of pixels $2P$. Where P is a number of sensor pixels, which define half of this edge. This value P we obtain if we know the position of inflectional points P_1, P_2 each of the transition and the order number S of middle pixel

$$S = \frac{P_1 + P_2}{2}\ ,\ P \le P_2 - S. \tag{7}$$

We determine the values P_1, P_2 as the order numbers of two pixels for which video signal levels are nearest to the middle value

$$F_s = \frac{F_{max} + F_{min}}{2}\ , \tag{8}$$

where F_{max} is maximum value and F_{min} is minimum value of video signal levels in Fig.2.

Now we determine the maximum middle value F_m as the statistical middle value of those video signal levels, which correspond to the white background. The minimum middle value F_n we determine as statistical middle value of those video signal levels, which correspond to the black measured object. We compute those levels F_m and F_n without levels, which correspond to each of the transition WHITE-BLACK and BLACK-WHITE.

We compute the value F for the equation (3) from the following equation

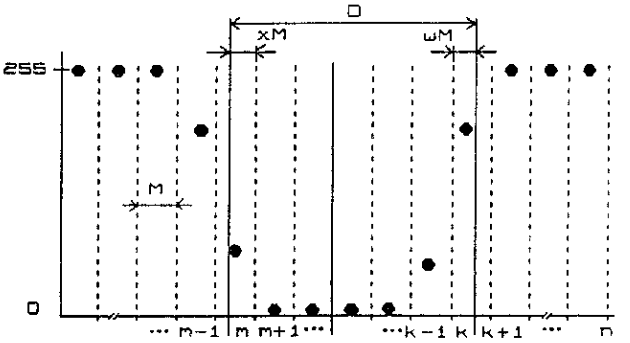

Fig.3
Interpretation of the computed parameters (IDE-ideal downward edge, IUE-ideal upward edge, S-middle)

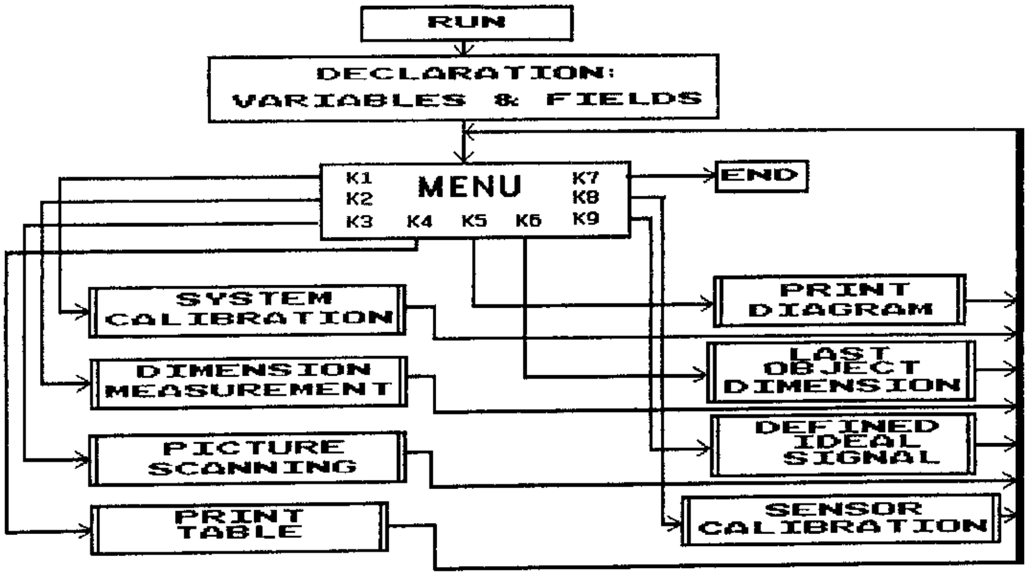

Fig.4
The block diagram of the program

$$F = \frac{\sum_{i=1}^{P}(F_i - F_n)}{F_m - F_n} \qquad (9)$$

The computations of those parameters F_s, S, P, F_m, F_n, F can be arranged into the algorithm, which is suitable for the computing program on a personal computer. The computed values m, $x.M$, k, $w.M$ are shown in Fig.3, for each of transition WHITE-BLACK and BLACK-WHITE.

The block diagram of the program for measurement of the object dimension, which was implemented on our measuring system is shown in Fig.4.

The dimension D of the measured object we obtain according to following equation

$$D = M(x + w + k - m - 1)\ , \qquad (10)$$

where the parameter M we obtain by the calibration of the measuring system.

3. Conclusion

A new modification of photometric method for edge detection is described. This method is suitable for measurement of the object dimension by using the digital camera with linear CCD sensor. This method can be realized by the algorithm, which is suitable for the computing program on a personal computer. The obtained results show, that the introduced method gives a possibility to raise the measurement accuracy of the object dimension considerably.

4. References

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