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PROCESSING SIGNALS CARRYING VISUAL INFORMATION AS A PROBLEM OF IMAGE RECOGNITION

C.M.Isaev
PhD, assistant professor of Karshi branch of Tashkent University of Information Technologies named after Muhammad al-Khwarizmi
A.F.Khayrullaev., G.R.Amirov
Master students of Karshi branch of Tashkent University of Information Technologies named after Muhammad al-Khwarizmi. Karshi city of Uzbekistan
alisher.xayrullayev@mail.ru

Annotation. Many modern methods of processing visual information (images) in such branches of science and technology as radiolocation, robotics, optical holography and many others are based on the use of pattern recognition methods. This article describes in detail the processing of signals carrying visual information, as the task of pattern recognition

Keywords: visual information, window function, spectrum of signal, photodiode, sensor, photosensitive surface, vector space

Practice shows that the expansion of their functionality and productivity can be achieved through further development of sensory devices and increasing the level of software (algorithms). The purpose of this work is a structural analysis of the system of automatic classification used in the tasks of processing visual information.

Figure 1 shows the block diagram of the automatic classification system, which is often used in the processing of visual information. Sensor 1 converts the physical quantity, coming to its input, into a signal intended for block 2

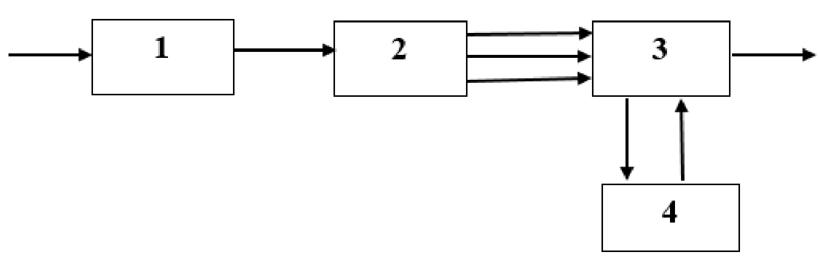

Figure 1.
1 - Primary measuring transducer (sensor);
2 - Preprocessing unit;
3 - Classification unit;
4 - Memory.

preliminary processing (usually the output signals of the sensors are electrical signals). This makes it possible to use sensors of various types. For digital systems, either sensors with a digital

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output are used, or an analog-to-digital converter is turned on after the analog sensor. For devices operating in real time, the characteristics of this particular node determine the characteristics of the entire system as a whole.

An example of an image signal sensor can serve as a photodiode array, each element of which in itself acts as an elementary sensor. Due to the mosaic structure of the photosensitive surface, the optical image is subjected to spatial sampling, which manifests itself in the output signals of the sensor.

The problem solved by the preprocessing unit is to select the characteristic features of an object or a family of objects in question. The first operation on this path is the operation of separating the area in which the object being presented is located. To do this, it is necessary to eliminate random distortions by means of hardware or software and smooth out noise that accompanies the input information arriving at different points in time or under different operating conditions. For visual images, pre-processing consists in detecting and centering the observed object inside the “window” (field of view). At this stage, other operations can be performed along the way: quantization, functional transformations, etc.

The theoretical basis for obtaining information about objects is communication theory and signal processing methods. This approach allows us to represent signals in the form of vectors. To do this, use the Fourier transform or other known methods. At this stage, one also has to use the filtering operation, i.e. signal extraction from noise. If we consider the frequency domain, then by this we should understand the selection of those energy components that interest the researcher [1]. In this case, in the process of filtering, individual frequencies or frequency bands are distinguished from the spectrum, carrying substantial information about the object being presented. These spectral components are associated with the characteristic features of a given object or, more precisely, with the components of a feature vector. The process of feature extraction can be considered as one of the types of filtering tasks: one-dimensional for a speech signal, two-dimensional for images, three-dimensional for scenes.

Such an approach is based on the adoption of a hypothesis, which states that all the characteristic features can be considered as components of the spectrum describing the represented object in a space chosen appropriately. In this case, the problem of obtaining the true spectral components in the generally accepted understanding of the term is not removed. We should not forget that a one-dimensional or multidimensional signal is limited in time (or space), at least according to the conditions of its observation. Such a restriction may distort or even completely change the nature of the signal. Let $f(t)$ be a signal, $\omega(t)$is a window function corresponding to the observation time. In this case, the dimension of the “window” function coincides with the dimension of the signal: one-dimensional for a signal, which is a function of one variable (time); for the image, a two-dimensional window $\omega(x,y)$is used. In the simplest case, this function can be described as follows:

$$\omega(t) = \begin{cases} 0 \ \ at\ t < t_0; \\ 1 \ \ at\ t \geq t_0; \\ 0 \ \ at\ t > T + t_0; \end{cases} \qquad (1)$$

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Where T is the duration of the window in time (Figure 2)

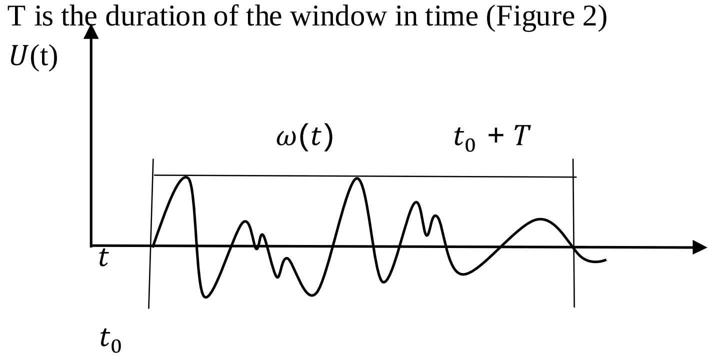

Figure 2. Window function

When analyzing visual information (images), the "window" function really plays the role of a window that cuts out a part of the scene in question, just as a television program transmitting to a camera with its field of view selects a certain plot from all possible ones that are currently in front of the lens.

The useful signal at the output window will be:

$$U(t) = S(t) * \omega(t). \qquad (2)$$

The spectrum of the useful signal can be calculated by performing the operation of convolving the spectra of the original signal and the function window:

$$U(\omega) = S(\omega) * W(\omega) = \int S(\omega) * W(\omega - k) * dk \qquad (3)$$

where * is the convolution sign.

If the window function has unlimited length, then its spectrum is narrowed and can be represented by the Dirac function (Figure 3). Then

$$\int S(k)\delta(k - \omega) * dk = S(\omega) \qquad (4)$$

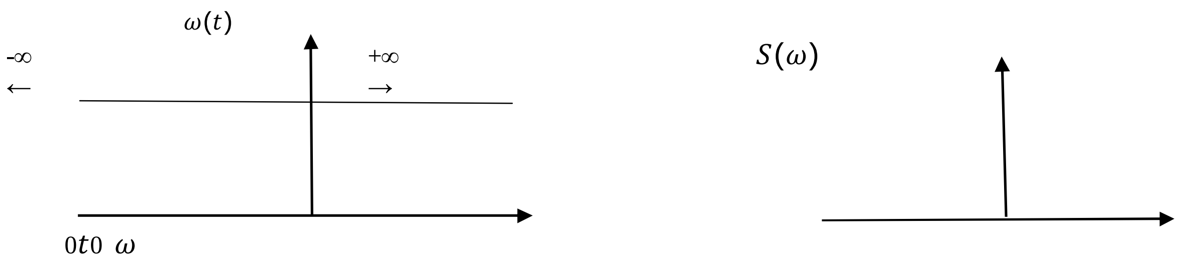

Figure 3. Spectrum of an ideal window

Such a window does not change the characteristics of the original signal. Actually used window functions are limited by temporal or spatial frames, and therefore their spectrum differs from the spectrum of the Dirac function (Figure 4). For example, the spectrum of a rectangular window is determined by the expression (Sim. Figure 4).

$$W(\omega) = 2AT[\sin(\omega T)/(\omega T)] \qquad (5)$$

Figure 4. Spectrum of a real window

The spectrum of a signal limited in time is different from the spectrum of an ideal signal of infinite duration. It is known that the spectrum of an infinite sinusoid is represented by a single spectral line, or Dirac function, while the spectrum of a sinusoid cut from it by a rectangular window expands in the world of how the signal duration is reduced.

In order to take into account and, if possible, weaken this undesirable phenomenon, use a window having the shape of a characteristic selected in a special way. In other words, certain weighting factors are selected for all signals that fall in the center of the window. In this case, an operation is performed on the signal, similarly, apodization in optics.

Other tasks related to signal conversion may be assigned to preprocessing. At the same time, convenience and speed of operations on a computer are taken into account.

The result of the operations performed in the preprocessing block is to obtain the characteristic features associated with the components of the multidimensional vector of the original measurements. Each object is displayed with a dot in the vector space. However, it is necessary to take into account that errors and errors may appear in the measurement process, measurement results are accompanied by noises of various origins, etc.

All this leads to the fact that the same family of objects shown is actually represented as a kind of “cloud” of points filling a certain area in space [2]. Suppose these spaces are separable. Then the classification procedure is to find for each region R_i a crucial function $g_i(\vec{x})$such that if

$$g_i(\vec{x}) > g_j(\vec{x}), \text{то } \vec{x} \in R_i \forall_j = 1,2,3,\dots,N;$$

where N is the total number of regions.

There are various ways to find such a decision function, or static decision rules. One of the most obvious ways to define them is the geometric representation of the space in which recognition is performed, and the construction of distribution surfaces in it [2].

The foregoing allows us to conclude that the processing of carriers of visual information can be reduced to the task of pattern recognition, i.e. to the classification task.

Literature

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