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Image Preparation for Processing in Video Surveillance Systems

The result of the image analysis algorithms directly depends on the input data. I.e. on the image with certain parameters. Image parameters can include brightness, contrast, digital noise level. Having properly processed the input image can greatly facilitate the task of analyzing the image and identifying ob-jects on it. This is about method of automatic selection of image correction technique in CCTV to prepare images for further analysis using different ways to identify objects in the image. This information is valuable in the field of computer vision systems that operate in a changing environment, where the characteristics of the image may change over time.

Computer vision systems are becoming more widespread and include not only the professional market segment (automatic navigation, car number recognition, military equipment identification, etc.), and also turned into a household and semi-professional sphere, which uses low quality video recorders, simplified software, no additional parameters for the configuration.

It is common for cameras within a low price segment that problems occur at time of analyzing visual scenes in which certain characteristics change dynamically, such as: changing the illumination that is associated with the time of day, weather conditions, etc. The result of work of image analysis algorithms depends on the input data. That is, on the image with certain parameters. The parameters can include the rate of brightness, contrast, digital noise level. Having properly processed the input image, it is possible to significantly ease the task of analyzing the image and identifying objects on it. Manual adjustment of image parameters, depending on the characteristics of scene, requires considerable resources. Thus, it is necessary to adjust the parameters of the image pre-processing for its further analysis, depending on the conditions of the scene under study.

One of the approaches to solve this problem is the construction of an expert model and algorithms of the logical decisions about the using certain means of adjusting the image parameters in video surveillance systems. The ones include correction of brightness and contrast, gamma correction, the use of filters to reduce noise, image conversion in grayscale, binarization algorithms, etc.

Before the process of identifying objects on a video image, analyzing its motion, etc., pre-processing of the image is preceded. It is a chain of transformations of the given image in a way that will facilitate its analysis. Thus, one of the tasks of pre-processing images is the allocation of an object in the image.

Influence of image contrast on the result of binarization on an example of the Bradley-Root algorithm

The Bradley-Root method for binarization of images shows good results for a homogeneous background, it also has low sensitivity to low contrast parts of the image (Fig. 1).

A) B) C)

Fig. 1. Examples of images to which binarization will be applied a) an image with 30% of the original contrast rate b) an image with an initial contrast rate c) an image with 170% of the original contrast rate

While using the Bradley method to binarize the low contrast image (Fig. 1a), the overwhelming part of the shadows on the image is ignored. This fact makes further identification of objects easier in contrast to the use of a high-contrast image (Fig. 1c). In this case, the original image gives an acceptable result (Fig. 2b), but the use of the result of binarization of a less contrast image will give preference in identifying a person with the help of Haar features. That is, such features, in turn, can be used to improve the accuracy of the selection of objects on the image.

A) B) C)

Fig. 2. Results of binarization of the initial image with the Bradley-Root method a) an image with 30% of the original contrast rate b) an image with an initial contrast rate c) an image with 170% of the original contrast rate

To increase the accuracy of the allocation of an object using the Bradley method it is proposed to apply a background subtraction algorithm before binarization. In this way all pixels of the background image will be removed. Thus, there will not be obstacles for further analysis (Fig. 3a). The choice of the

binarization method also affects the accuracy of the allocation of the object at the scene. The use of threshold binarization has several advantages, such as the simplicity of implementation of this algorithm and the speed of execution, which are very important in the processing and analyzing the video images in real time. However, the disadvantage of this algorithm is its sensitivity to shadows (Figure 3b), which prevents further analysis of the image. Using the Bradley binarization method, which is refered to adaptive binary methods, allows to bypass the problem with high sensitivity to the shadows and more precisely allocate the silhouette of the object on the image (Fig. 3c).

A) B) C)

Fig. 3. Representation of the images obtained during the study of the scene: a) the image obtained after the removal of the background, b) the image under using the threshold binarization, c) the image under using the Bradley method.

The use of the threshold binary algorithm shows satisfactory results when solving motion detection problems on the images, but it is not enough to prepare the image for further identification of objects on it. Objects on the resulting binary image can be identified using the Viola-Jones method or Haar features.

Based on the obtained results, it can be stated that since Bradley-Rot's binarization method is sensitive to image contrast, the optimal binary result can be achieved with certain image contrast values. If the contrast level of the image is too high it is necessary to reduce it to the optimal level, otherwise to increase it. The contrast of the image (as well as its brightness) may vary depending on the time of day, weather conditions, etc. Thus, there is a need to adjust the parameters of the input image during operating the system.

Expert System

To solve the problem of automatic correction of image parameters in systems of computer vision it is suggested to use an expert system. Therefore, the following logic-linguistic model is presented:

Object of management (OM) is a system of analysis of objects on a video image.

A situation that requires managerial influence is an insufficient or an overwhelmed contrast of the image elements.

The OU element, which is the place of manifestation of a collision, is the input image (*a*).

Characteristic of the state of the OM element is the value of the contrast of the image $k(a)$.

Necessary result of realization of managerial decision is the reduction of the contrast rate of the image to the established optimal level [*OPT(k(a))*].

Possible managing operations k

Increment of the image contrast rate [*incr_CNTRST*];

Decrement of the image contrast rate [*decr_CNTRST*].

The OM element, which is the object of implementation of the managing operation, program module of an image pre-processing(b)

Necessary conditions for performance management operations for correction of image contrast:

- insufficient image contrast rate [INSUFF(k(a))];
- overwhelmed image contrast rate [OVERWH(k(a))].

Required resources for implementation of the management operation:

suboptimal contrast rate of the image *a* [*CNTRST(a, subopt)*];

Expressions that describe the possible ways of influence the OM:

$$\forall a \forall b[\text{INSUFF}(k(a) \,\&\, \text{REAL}(incr\_CNTRST(a)) \rightarrow OPT(k(a))]$$

$$\forall a \forall b[OVERWH(k(a)) \,\&\, REAL(decr\_CNTRST(a)) \rightarrow OPT(k(a))]$$

where REAL is a predicate with the meaning "to be realized".

Expressions that describe the conditions for realization the managing operations:

$$\forall a \forall b[\text{CNTRST}(a, subopt) \rightarrow RES(incr\_\text{CNTRST}(a))]$$

$$\forall a \forall b[\text{CNTRST}(a, subopt) \rightarrow RES(decr\_\text{CNTRST}(a))]$$

Where RES is a predicate that reflects the presence of resource.

An expression that means the need to implement a management operation under conditions if it can lead to the desired result and the existence of resources for this operation.

$$\forall x[DECIS(x) \,\&\, RES(x) \rightarrow REAL(x)]$$

$$\forall a \exists x[DECIS(x) \rightarrow OPT(k(a))]$$

Where DECIS is a predicate that reflects the existence of a solution to the problem under consideration.

In addition, the choice of the method of correction of the image is influenced by other characteristics of the scene. A tree of possible scene characteristics was constructed. It may depend on the choice of how to preprocess the image (Fig. 4). Thus, an expert model that takes into account all of these characteristics will be much more complicated than presented only to characterize the contrast of the image. The impact of other image characteristics on the process of identifying objects requires additional research to identify the optimal values of these parameters or methods of working with scenes having such characteristics.

There is a description of the input and output parameters of the system state:

x_1 – Brightness rate of an image

x_2 – Contrast rate of an image

x_3 – Color saturation

x_4 – Number of colors

x_5 – Homogeneity of the background

x_6 – Power of digital noise

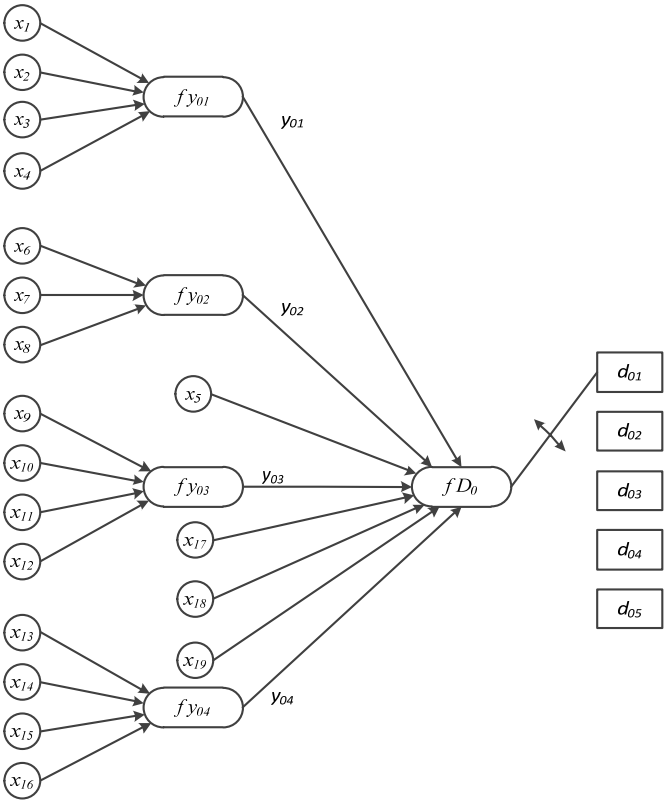

Fig. 4 Tree of system status parameters.

There is a description of the input and output parameters of the system state:

x_7 – Bitrate of streaming video
x_8 – Image size in pixels
x_9 – Scene placement (interior)
x_{10} – Scene placement (exterior)
x_{11} – The position of the source of the lighting of the scene
x_{12} – Night shot mode
x_{13} – Camera location height
x_{14} – Angle of the camera location relative to the scene
x_{15} – The perspective of the stage
x_{16} – Camera lens type
x_{17} – Number of frames per second after frame processing
x_{18} – Number of frames per second of streaming video
x_{19} – The task of video analysis
y_{01} – The need for color correction of the image
y_{02} – The quality of the input image
y_{03} – Illuminance of the scene
y_{04} – Camera location
D_{01} – Conclusion on the necessary image processing chain
d_n – Possible action as a result of the adopted decision

To solve this problem, fuzzy sets theory can be applied, which implies the representation of state parameters in the form of linguistic variables. Formalization of linguistic terms within the fuzzy set theory is carried out with the help of membership functions. In applied fuzzy systems, membership functions can be set either parametrically or constructed by special techniques as a result of additional expert polls. The most common techniques of membership functions construction are based on the statistical processing of expert information and on paired comparisons. These methods are used mainly in the development of pure expert systems. Pure expert systems are systems where only expert information is used. Systems of decision-making, with the mechanisms of training are developing rapidly. In these systems, expert knowledge is used to form a coarse decision-making model. And for its configuration (learning) experimental data are used. Membership functions of terms and rule weights play role of parameters for configuration in the fuzzy decision-making models.

Conclusions

An analysis of the effect of image contrast rate on the result of the Bradley-Root binarization and the threshold binarization methods was performed. As a result, it was found that the Bradley-Root method is sensitive to the contrast rate of the image. This means that this method ignores the low contrast elements of the image, which helps to cut off elements that do not have a high sense for analysis (elements such as shadows, shallow parts of the interior and exterior, etc.).

In order to correct the image by the criterion of contrast rate, an expert model was constructed. It allows to make managerial decisions under condition this image characteristics are deviated from the set optimal value. Optical value may vary depending on other characteristics and video image analysis task.

A tree of possible scene characteristics was constructed. The choice of the method of pre-processing the image depends on these characteristics. At the time of the writing of the article, the effect of only a small number of selected characteristics of the scene on the processes of pre-processing and identification of objects is investigated. The influence of other characteristics will be analyzed in the course of further research. The application of this expert model in computer vision systems will allow adjust the image parameters automatically to satisfy the set task.

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