BACKGROUND IMAGE GENERATION BY COOPERATIVE PARALLEL PROCESSING UNDER SEVERE OUTDOOR CONDITION

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ABSTRACT

This paper proposes a system for the background image generation by cooperative parallel processing under the severe outdoor environmental conditions, which are ever changing in nature. Software of this system is composed of four individual modules. Each module function by exchanging the information which is resulted from the processing in other modules. Each module is implemented on the hardware system of parallel processing composed of the transputers(T805) network according as its properties.

The effectiveness of this system is examined on the real outdoor scene practically. As the result, the system suitably responds to such environment and the correct background images can be generated. It is confirmed that the cooperative parallel processing enables the system to be highly flexible and adaptive to various conditions.

1. INTRODUCTION

In many computer vision systems, the distinction between the object and background image is one of the important task in image processing, and has influence on performance of the whole system directly. However, the correct background image generation, especially under the outdoor environmental condition, is not an easy problem owing to many disturbing factors[1]. If the background image can be exactly determined, the target object can be easily extracted by the comparison with the input image.

From this point, the cooperative parallel processing system[2] is proposed for the purpose of the correct background image generation. The system is composed of four individual modules to make parallel processing more effective. These four modules work cooperatively by exchanging the information of the processing results in the respective modules.

The outline of the algorithm in each module and the information exchange among the modules is described in the followings.

2. BACKGROUND IMAGE GENERATION

It is necessary to determine the exact background image for extracting the target object from the picked-up scene. Certain restrictions must be set as the property of the background to distinguish it from the object. Therefore, the background is assumed to be not changing at all or only slowly changeable compared with the object in this study. A few frames of the images are needed to determine the exact background information under this assumption. A time series of image frames is compared with each other and relatively stable region in the images are taken as the background.

This method has two problems, however. The one is that it is difficult to obtain the background information on the unstable regions in the image. The other is that it may be judged that only background exists in the image in case the object is at a stop or moves very slowly.

The images should be input at certain time intervals and the processed results should be obtained on the basis of the information extracted from enough number of images picked up during certain period of time to avoid these problems. The processing modules shown in the followings are constructed on sufficiently considering these matters.

2.1 BACKGROUND GENERATION MODULE 1 (MODULE 1)

The processing with this module extracts the regions where the brightness of the time sequential 3 frames of input images is not change so remarkably, and decides the background. The principle of the generation processing of the background from 3 frames is illustrated in Fig. 1. The (absolute) difference image 1(D1) is calculated from the input image 1(I1) and 2(I2), and the deference image 2(D2) is from the image 2 and 3(I3) respectively. The logical product image(L0) is calculated by the logical product operation between

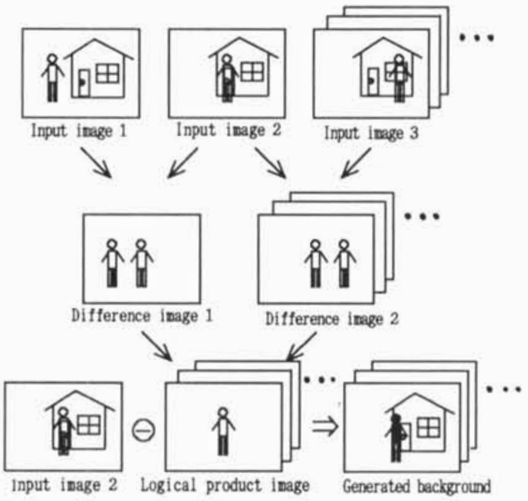


Fig. 1 The principle of 3 frame background generation processing

the deference images D1 and D2. Then, the moving object in the input image 2 is excluded by subtracting the image L0 from the image I2. The same operation is repeated to the consecutive input images until the complete background is obtained. The background image generated for the first time is defined as the initial background image. Figure 2 is an example for the initial background image.

The function of this module(Module 1) is different from the module described in the later section, in the respect that the former can determine the background on the basis of the newest picked-up images, so the feature of this module is quick response.

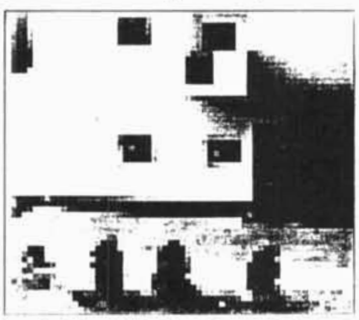


Fig. 2 The initial background image

2.2 BACKGROUND GENERATION MODULE 2 (MODULE 2)

This module begins to act after the initial background image is determined in the module 1 and transmitted its data. The processing steps are as follows;

Step 1. Calculate the absolute difference of brightness value between the back ground image and the input image.

Step 2. Threshold on such difference image and determine the moving object regions where the changes of the brightness exceed over certain level.

Step 3. Register regions which are connected to the determined region at Step 2 within 8 neighboring pixels each other as unit segment and attach the segment number.

Step 4. Evaluate the area, the gray level, the shape coefficient and the moving distance of each unit segment as the feature index of registered segment.

Step 5. Delete the any segment whose feature indexes are lower than the preset threshold level.

Step 6. Determine the background by excepting the rest of segments as the moving object(unstable) region.

The distinction of the object from the background is performed by using the already existing background data in this module(Module 2).

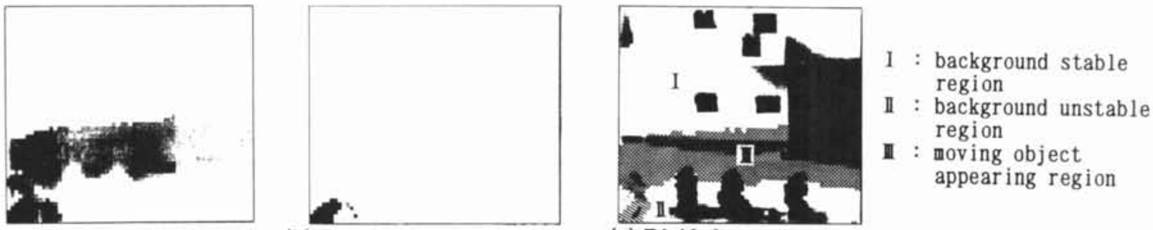
2.3 BACKGROUND DESCRIPTION MODULE (MODULE 3)

There are some regions which are judged as the moving object, owing to their brightness data unstableness, in Module 1 or 2, although they should originally belong to the background. The typical example for them is the nodding trees in the wind. Such "misdistinction" may directly cause an adverse effect on the performance of the whole system. The appearance frequency and the motion analysis are used to identify such regions in this module(Module 3).

Two buffers, the appearance frequency buffer(AFB) and the motion analysis buffer(MAB) are prepared in this module. Both of buffers have the counters which correspond to the every pixel of the image respectively. Corresponding parts of all these counters respond to the unstable regions extracted in Module 1 or 2. The counters of AFB are incremented according as the appearance of the unstable regions. The counters of MAB are incremented every case the directions of the motion of the unstable regions change. The change of the motion direction is detected by the template matching method. The image plane is divided into three regions as background stable region, background unstable region and moving object appearing region, and the weight values are given to these regions respectively on the basis of the countings in these two buffers. The countings in AFB and MAB are shown in Fig. 3(a) and (b) respectively. The divided three regions is shown in Fig. 3(c).

2.4 BACKGROUND RENEWING MODULE (MODULE 4)

It is impossible to determine the background correctly in case the sudden and remarkable changes occur in the background scene even if the above mentioned



(a) The appearance frequency buffer(AFB) (b) The motion analysis buffer (MAB) (c) Divided 3 regions of image plane

Fig. 3 Described background by using AFB and MAB

three modules may function efficiently. Therefore, it is necessary to append the routine, which can response to the ever-changing background, to the processing algorithm. The background image is renewed by the brightness data of the newly input image data according to Eq. (1), given below, in this routine. The data renewed regions have been decided by Module 1 and 2.

$$M_B(i,j,t) = \frac{(2^n - 1) * M_B(i,j,t-1) + M_I(i,j,t)}{2^n} \tag{1}$$

,where

$M_B(i,j,t)$: brightness value of pixel(i,j) of the generated background image at time t

$M_I(i,j,t)$: brightness value of pixel(i,j) which is decided as a background in the input image at time t

n : arbitrary integer $(n \geq 1)$

In the above equation, the first term of the right hand side has the property of the background image which has been accumulated and averaged from the past till the present. The second has the information on the present state of the background. The value of n manages the response of the renewing. This renewing module can response against the sudden change of the background image sensitively, but it may be apt to become unstable for the small value of n. In this study, n is set to 1 to realize the comparatively fast response with sacrificing stableness.

3. COOPERATIVE PARALLEL PROCESSING

Four processing modules described in the previous sections are implemented on the parallel system composed of the transputers(T805) network according as the properties of each module. The processing algorithm in each module is coded in the parallel processing language, OCCAM[3], so as to well match the transputers. Each module works independently at the early processing stage, but the cooperative processing starts at the stage when a certain processing finishes, some results are obtained and, on the basis of these results, information exchange with other modules becomes possible in each module. The cooperative processing can be realized by exchanging information and adjusting the processing flow and the processed data. The information to be exchanged among the four modules is schematically shown in Fig. 4.

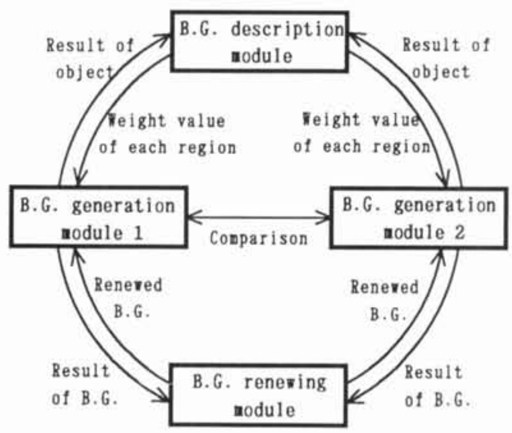


Fig. 4 Cooperative processing of four modules

The concrete processings in each module are as follows;

1. The initial background generation process starts at the routine in Module 1 when the brightness data unstable region appears in the input image. This process continues until the complete initial background image is generated. The image data generated in this routine are transmitted to Module 2.

2. The process in Module 2 starts immediately after it receives the initial background data. The background generation process proceeds in both of Module 1 and 2 independently by using the initial background information at the starting point, and then, using the same image data picked-up successively. The regions not belong to the background are extracted from this input image, also independently in Module 1 and 2, on the basis of the generated background information.

3. The extracted results in Module 1 and 2 are compared. The comparison is made on the number, the area, the shape, the amount of the movement and its direction of the extracted regions. Judgment on the

Table 1 The number of the object extracted only by Module 1

Unit (%)

Co.\In.	0	1	2	3	4	5
0	96	4				
1		95	5		0	
2		8	80	11	1	
3			16	80	4	
4		0		19	77	5
5				12	20	68

Table 2 The number of the object extracted by cooperative parallel processing

Unit (%)

Co.\In.	0	1	2	3	4	5
0	98	2				
1	1	97	2		0	
2		8	87	6		
3		6	10	83	1	
4		0	7	12	81	
5			3	9	12	79

In. : interpritated number of objects

Co. : correct number of objects

comparison is performed on the basis of the knowledge on the object scene which was stored beforehand in each module.

4. The input image is divided into the several regions in Module 3 according to the processing results from Module 1 and 2. The accumulating calculation is carried out for these regions and the weight values are attached respectively on using calculated results. The weight values are referenced and used by the background generation process in Module 1 and 2 to make their functions more reliable.

5. The information on the boundary positions of the background regions is sent to Module 4 from Modules 1 and 2. The renewed data within these boundaries are sent back to Modules 1 and 2.

The background image can be successively generated and become more reliable with time elapses through this cooperative processing.

4. EXPERIMENT

For the purpose of the evaluation of the developed system, the experiment was made on the natural outdoor scene. The scene was set to the exit of a building and the road in front of it. This scene also includes the trees planted here and there. The images of this scene, together with the persons, who were walking on the road and going in and out through that exit, were picked up from the opposite side beyond the road. The picked up images were recorded with VTR. The image recording was done in four hours. The sunshine condition and the wind condition changed within this period.

The image processing with the system was carried out for about 10,000 frames of the recorded images. The output signal from VTR was converted into 256x240 pixels, 8 bits digital data and a series of processings were made. The processed results were obtained at intervals of about 200 miliseconds in average.

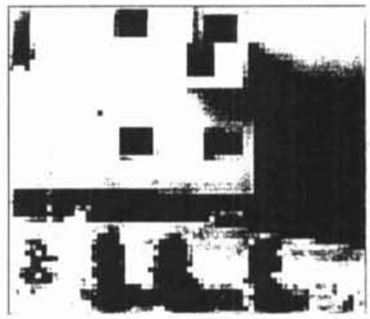


Fig. 5 Generated background image after 1 hour elapsed

The results are shown in Tables 1 and 2. The number of the brightness unstable regions which were extracted by only the Module 2 is shown in Table 1. Table 2 was obtained as the result of the cooperative parallel processing. In Table 1, the result is influenced by the disturbing factors such as time varying sunshine, nodding trees in the wind and so on. However, the effect of these disturbing factors are removed by the cooperative parallel processing as is seen in Table 2. The background image generated in one hour during this experiment is shown in Fig. 5. It is understood that the background image is suitable generated to the ever-changing scene.

5. CONCLUSION

In this paper, for the purpose of accurate background image generation under the severe outdoor environmental condition, cooperative processing is proposed and implemented on the parallel network system. The system is composed of four separate modules with different properties, and all modules are organically related and exchange the information each other. The effectiveness of this system is examined on the real outdoor scene.

As a result, the algorithm is suitably responded to the ever-changing outdoor environment and the correct background images could be extracted. It is confirmed that the cooperative parallel processing enables the system to be highly flexible and adaptive to various conditions.

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