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Moving Object Extraction by Parallel Processing†

—Machine Vision Monitoring System (Report I)—

Katsunori INOUE* and Wonchan SEO**

Abstract

This paper is the work concerned with the building up of machine vision monitoring system, in which moving object extracttion algorithm has been developed and paralled network system has been constructed.

As the processing algorithm at the first stage, the image data are divided into thousand dozens number of blocks and operations are made for each block unit for simplifying the algorithm and saving the calculation cost. Then, the renewal algorithm for ever-changing background scene is also constructed by using the newest input image to attain robustness for the outdoor environmental condition.

As the second stage, the image input hardware that gives high flexibility on the constructed parallel network system is developed. The pipeline and parallel distribution processing algorithms are implemented on this parallel network system.

As the result, high speed and high effective parallel network system to monitor moving object extraction can be achieved.

KEY WORDS: (Machine Vision Monitoring System), (Moving Object Extraction), (Parallel Prossing), (Transputer Multi-processing System), (Image Recognition), (Outdoor Environment)

1. Introduction

For the purpose of the development of image processing system where a large volume of data should be processed, there are many attempts[1),2)] to achieve high speed calculation using with the parallel processors in the fields of engineering application and the superior results of parallel processings have been reported.

On the other side, high effective image recognition system that could be applied in global environmental condition is required. That is to say, there is no enough satisfactory developments that can show an excellent performance with robustness under the severe condition of outdoor environment that is ever-changing by nature.

In this study, the parallel processing system composed of the multi-processors is applied to the machine vision monitoring that can recognize and extract the moving object under the outdoor environment. The transputer (INMOS Co. Ltd., U.K.) is used as the parallel processing unit because of its easiness and flexibility for multi-processor.

As the processing algorithm at the first stage, the image data are divided into thousand dozens number of blocks[3)] and operations are made for each block unit for simplifying the algrithm and saving the calculation cost. Then, the renewal algorithm for ever-changing background scene is also constructed by using the newest input image to attain robustness for the outdoor environment condition.

As the second stage, the image input hardware that gives high flexibility on the constructed parallel network system is developed. The pipeline and parallel distribution processing algorithms are implemented on the parallel system composed of transputer network.

At the final stage, efficiency and effectiveness of the parallel processing system is examined on the natural outdoor scene practically.

2. Algorithm

2.1 Image Input and Pre-processing

The image data with 512×480 pixels input from the pickup device are divided into 128×120 blocks (so, each block has 4×4 pixels.) and mean level of each block data is used to set up for the standard brightness data of a background scene which is to be compared with that of the monitored image and the irregular object which does not exist in the background is to be extracted. The standard data used for this purpose is renewed by using the images

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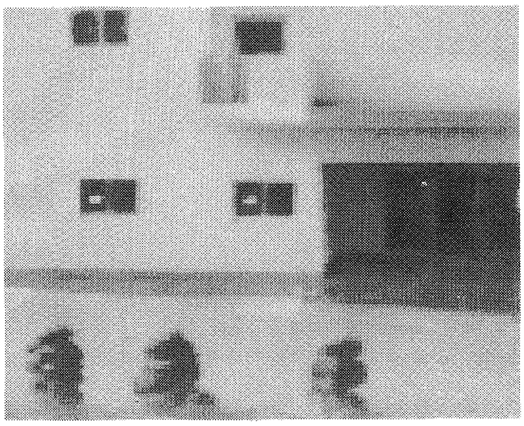
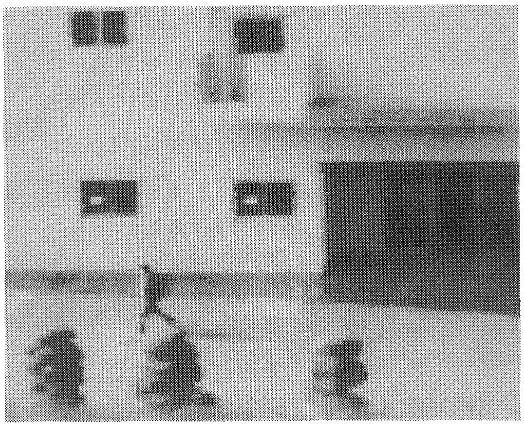


(a)



(b)

Fig. 1 Examples of input images after the pre-processing
(a) moving object not exists
(b) moving object exists

which have picked up previously according to the algorithm as described later. The influence of the time-dependent change of high-light parts and shadowed part in the monitored image owing to the change of sunshine lighting on the monitoring performance can be avoided effectively by this processing. Therefore, smoothing and histogram flattening which is usually required for the standard data setup is not necessary. **Figure 1** shows an example of input image after the pre-processing.

2.2 Renewing of Standard Data

Renewing the standard data is carried out by using the data of 128×120 blocks according to Eq. 1[4] given below.

$$M_S(i,j,t)=\frac{(2^n-1)\cdot M_S(i,j,t-1)+M_I(i,j,t)}{2^n} \qquad 1)$$

, where

$M_S(i,j,t)$; mean level of block(i,j) of standard data at time t

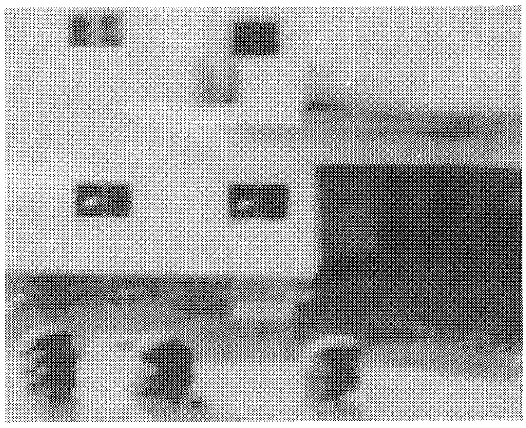


Fig. 2 The standard data corresponding to Fig. 1(a) after 1 hour elapsed

$M_I(i,j,t)$; mean level of block(i,j) of input image at time t.

n ; arbitrary integer ($n>=1$)

In the above equation, the first term of the right hand side has the property of the standard data which has been accumulated from the past till the present. The second has the information on the present state of the background scene. The value of n manages the response of the renewing, for the small value of n, the standard data can move against the sudden change of the back ground image sensitively, but it may be apt to become unstable. In this study, n is put to 1 so as to realize the comparatively fast response.

Figure 2 shows the standard data corresponding to Fig. 1(a) after 1 hour elapsed.

2.3 Thresholding of Difference Image

It is possible to determine the region from the absolute values of difference between the standard data and input image data to be monitored. We call these data of absolute values as difference image. After smoothing process, the thresholding process is performed on such difference image and can be determined the abnormal regions where the changes of the brightness exceed over certain level. The automatic threshold selection method[5] is adopted for this thresholding. We call the image composed of such abnormal regions as an abnormal object image.

Figure 3 shows an example of abnormal object image which corresponds to Fig. 1(b).

2.4 Moving Object Extraction

From the abnormal object image obtained from the difference image, the moving object regions can be extracted. The processing step for this extraction are as follows:

Step 1. Register regions which are connected with 8 neighboring pixels each other as unit segment and attach

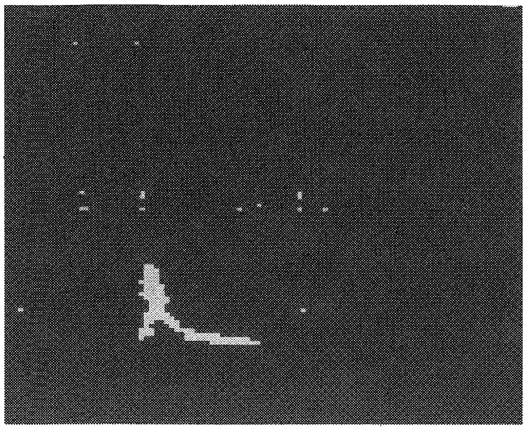


Fig. 3 Abnormal object image corresponding to Fig. 1(b)

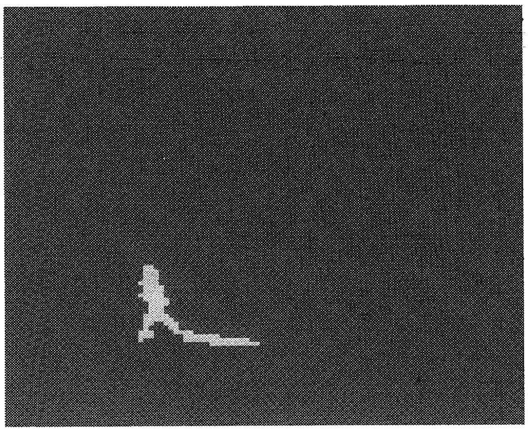


Fig. 4 Result of moving object extraction from Fig.3

the segment number.

Step 2. Evaluate the area, the mean gray level, the shape coefficient and transfer distance of each unit segment as the feature indexes of registered segment.

Step 3. Delete the any segments whose one of feature indexes is lower than the preset threshold level which is given for each feature index.

Step 4. Determine the rest of segments as moving object region.

Step 5. Utilize the background region by excepting above moving object region from the whole region of image plane.

Figure 4 shows the result of object extraction from Fig. 3.

3. Parallel Processing Network

In the parallel processing, the network of rough connected multi-processor system has such advantages as its scale and structure can easily be changed according as the problem to be processed by hardware connection and/or software instruction. The transputer (T800, 30MHz), as the element of multi-prossing, is used because of its easiness for setup, flexibility for scale up and abundant software resources. The pipeline and parallel distribution processing algorithms are implemented on the multi-processor network system constructed by the transputers which amount to 15 units at maximum. Parallel distribution processing program in this work is coded in parallel programming language, 'OCCAM'[6),7)]. High ability hardware for image data input, pre-processing and storing is used in this study. This hardware has recently been developed and it is suitable for the transputer multi-processor system.

3.1 Image Input hardware

As mentioned above, in the parallel processing of rough connected multi-processor system has many advantages. However, in image processing system that should calculate a huge amount of image data, the compose of hardware is limited by the structure and the speed of input image data. In other words, the efficiency and the processing speed of parallel system is influenced by the input device. Therefore, the image input hardware that gives high flexibility and high ability on parallel processing network system has been developed. The block diagram of the image input hardware used in this study is shown in **Fig. 5.**

The characteristic features of this image input hardware are as folows:

* Parallel processing with two on-board-processors (transputers) is possible.
* The communication with 8 processors at the same time is possible.
* With 3 DSP, filtering process (7×3 pixels of 3 frames or 7×9 pixels of 1 frame) is possible at real-time.
* The board has an extensity for VRAMs, DSPs, and on-board-processors.

By using above functions, high speed, high efficient and high flexible parallel network system that is less restraint upon the data input hardware can be constructed.

3.2 Communication Process

Execution of parallel program on multi-processor network requires a partitioning of the processing into sub-modules. Each processing in these sub-modules is performed independently, but it is sometimes necessary to communicate and exchange information among processings in sub-modules. The transputer used as the processing element has a function of message passing method for communication. Thus, to achieve free message communication among processes, each processing module should be consisted of communication process and calculation process. Each calculation process is synchronized with the communication signal through the communication process and executed cooperatively. Communication process in a sub-module is shown in **Fig. 6.**

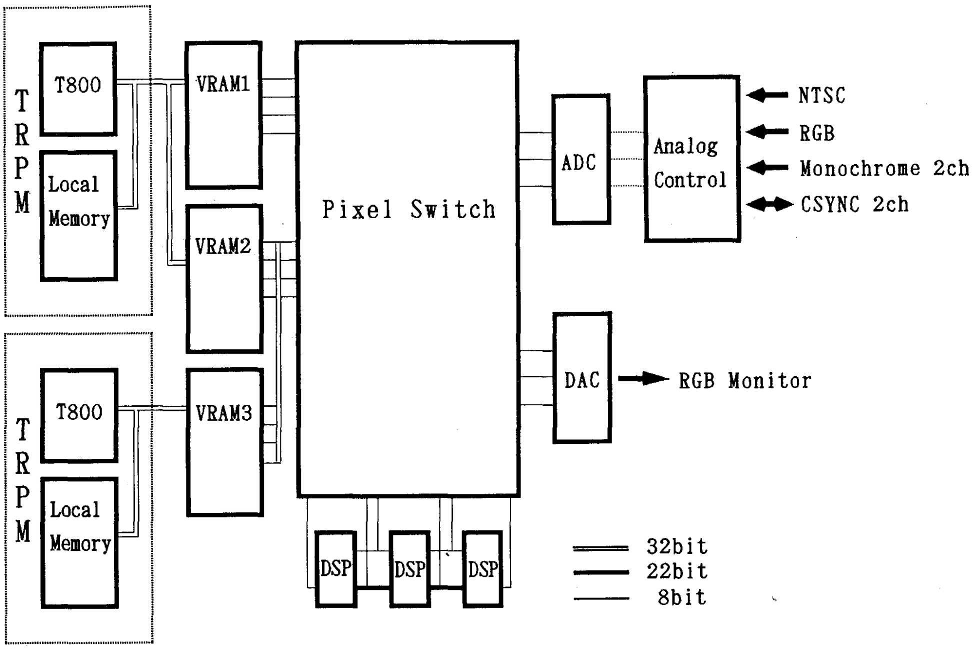


Fig. 5 Block diagram of image input hardware

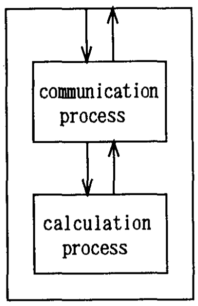


Fig. 6 Communication process in sub-module

command	---	contents of processing
from	---	sending process
to	---	receiving process
data	---	data for processing

Fig. 7 Communication protocol

The communication is done through the channel assigned by program under the protocol which is shown in **Fig. 7.**

3.3 Parallel Network System

Two main parts of processing algorithm in the parallel network system are pipeline processing and parallel distribution processing algorithms. These two algorithms have merits and demerits, and, so as to confirm a network system high ability, it is necessary for the two algorithms to counterbalance each other according as the problem to be solved. Parallel processing algorithm on image processing has a sequential trend that is one pocessing should be executed after the end of former processing. Therefore, the selection of optimum algorithm for each processing module is not a easy problem at the construction of parallel system. In this study, the moving object extraction algorithm discribed the former chapter is distributed for each processor to be equally loaded to reduce the overhead for the message communication. The result of constructed parallel network system is shwon in **Fig. 8.**

As is shown, the network is consisted of four parallel distribution processings and each parallel distribution processing is executed by pipeline processing.

The whole system is composed of four modules, such as image input & pre-processing module, standard data renewing & abnormal region detection module, feature calculation & moving object extraction module and display & system control module. Each module is consisted of several processes and each process has communication process and calculation process as described. The frame rate of input image is controlled by the processing time. All processes can be executed with small quiescent time and minimum overhead.

4. Results

Two experiments have been done on the parallel efficiency and the effectiveness of monitoring system to evaluate the constructed parallel system.

4.1 Parallel Efficiency

The processing time to get the value of 'area(%)' is measured, since the processing speed of whole system is

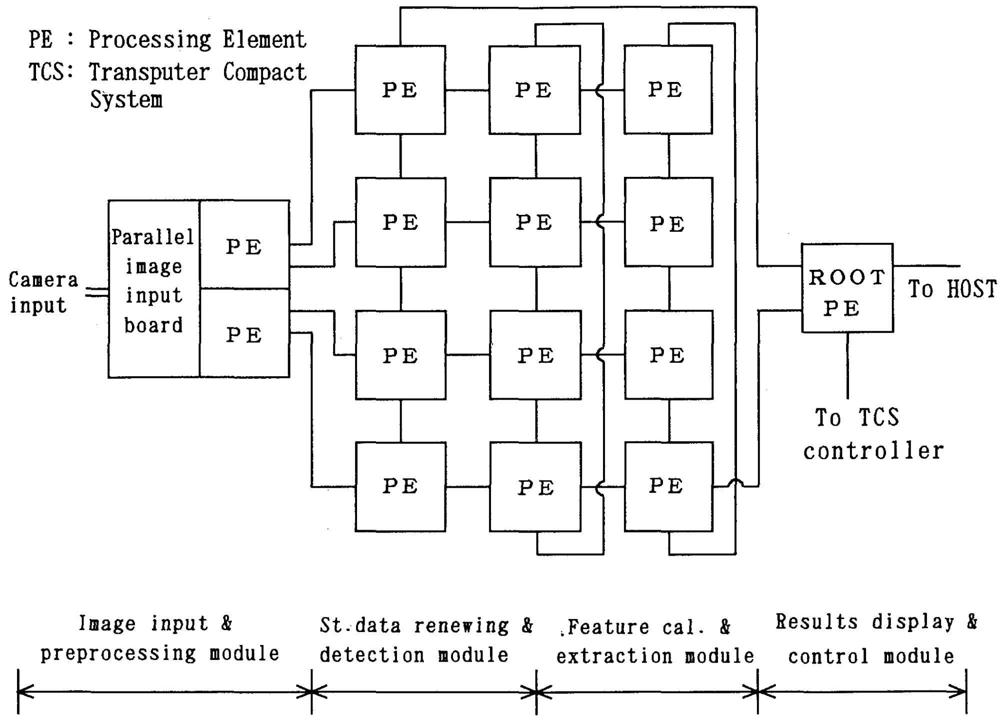


Fig. 8 Constructed parallel network system

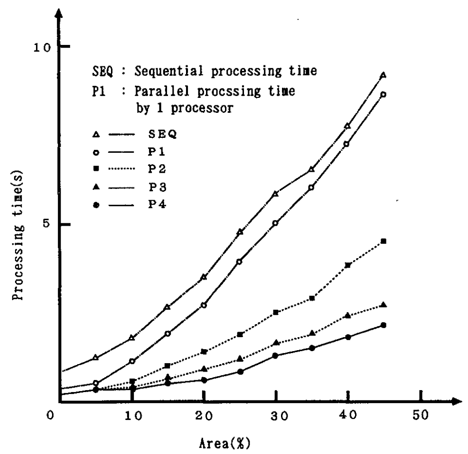


Fig. 9 Processing time vs. area(%) for number of processors(per 1 frame)

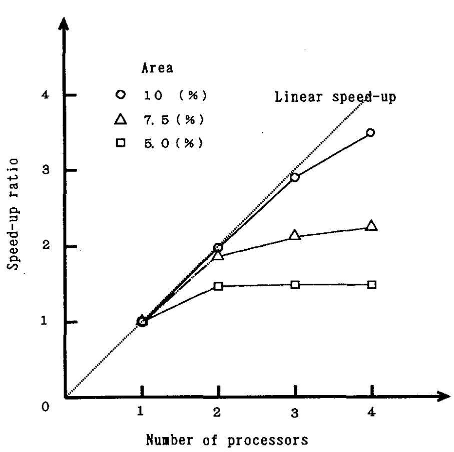


Fig. 10 Speed-up rate vs. number of processors and area(%)

governed by the amount of moving object region. The area(%) is given in Eq. 2.

$$\text{Area}(\%)=\frac{\text{Block number of moving object region}}{\text{Block number of input image}}\times 100 \quad (2)$$

Figure 9 shows the measured results of processing time vs. area(%) for various numbers of processors. **Figure 10** shows the speed-up ratio, which is given in Eq. 3 to evaluate the parallel processing efficency, on the same relation as Fig. 9.

$$S_p=T_1/T_n \quad (3)$$

, where

S_p : Speed-up ratio
T_1 : Parallel processing time with 1 processor
T_n : Parallel processing time with n processors

From Figs. 9 and 10, it is seen that almost linear speed-up is obtainable for the area increase of about 10%. This means that the constructed parallel system has a good performance. However, when the area of moving object region is small (<5%) the processing speed does not improve even if the number of processors increase. This is owing to the reason that the portion of communication in total process increases for the small size of area. Consequently, the effect of communication overhead becomes relatively larger.

4.2 Evaluation of Effectiveness

This section is related to the experiment for the evalua-

Table 1 Result of object recognition

Unit (%)

Cor. \ Int.	0	1	2	3	4	5	6
0	98	2					
1		95	5			0	
2		8	80	11	1		
3			16	80	4		
4		0		19	77	5	
5				12	18	68	2

Processing time : about 220ms/frame
Int. : interpritated number of objects
Cor. : correct number of objects

tion of effectiveness of the constructed parallel network system. The system composed of four parallel distribution processings as shown in Fig. 8 is applied to the extraction of moving object under the outdoor environmental condition.

The monitoring object in this experiment is the neighbourhood of the entrance of a building. The input image data were recorded with the video camera by observing from the 3rd floor of the other building in opposite side. The image data were recorded from 11:00 a.m. to 1:00 p.m. for two days. The recorded image data of 20,000 frames selected from 4 hour's video tape were processed in the experiment. The recognition results are shown in **Table 1**.

As is seen in Table 1, the recognition ability is high, but it decreases as increasing the number of objects. The reason is: difficulty of separation between moving objects and their shadows increases as the number of objects increases due to overlapping of the images of the objects themselves or the objects and shadows. The processing time per one frame is about 220 ms. This means that the system can recognize and extract moving object region from 4.5 frames per one second and it is enough significant value from the practical view.

5. Conclusion

In this study, the input data is divided into thousand dozens number of blocks and operations are made for each block unit. The renewal algorithm for ever-changing background scene is constructed by using the newest input image. This results in simplifying on algorithm and saving on calculation cost. The renewal algorithm can make the system to response positively on the effects of the outdoor environmental condition which is ever changing. As a result, the robust algorithm on the moving object extraction under the severe condition of outdoor environment can be established.

For the construction of parallel network system, an image input hardware is developed and the system is consisted of the pipeline and parallel distribution processing algorithms according as the characters of each processing module for moving object extraction. From these attempts, it is possible to give high flexibility for the compose of parallel network system, and the high speed and high effective system by reducing amount of communication, equalizing the load, and decreasing the communication overhead can be attained.

It was confirmed by the experiment that the parallel network system developed in this work has a good performance and high effectiveness for moving object extraction.

References

1) Masahide KANEKO, Atsushi KOIKE and Yoshinori HATORI: "Flexible Parallel Picture processor FP3 and Its Application to Various Types of Image Processings", IPIJ Technical Rept. on Computer Vision, 57—5(1988)(In Japanese).

2) Shirin EGHTESADI and Mark SANDLER: "Implementation of the Hough Transform for Intermediate-Level vision on a Transputer Network", Microprocessor and Microsystems, Vol. 13(1989), No. 3.

3) Takeshi AGUI. Tomoaki SAITO and Masayuki NAKAJIMA: " An Extracting Method of Walking Persons Using a Series of Images", IEICE conf. , SD-11-5(1990)(IN Japanese).

4) Atsushi KAWABATA, Shinya TANIFUJI and Yasuo MOROOKA: "An Image Extraction Method for Moving Object", Trans. IPSJ, Vol. 28(1987), No. 4, 395—402(In Japanese).

5) N. OTSU: "A Threshold selection Method for Gray-level Histograms", IEEE Trans. , Vol. SMC-9, Jan. (1979), 62—66.

6) Transputer development system 2.0, INMOS, Beta 2 documentation.

7) Transputer reference manual, INMOS, Oct. (1986).